A STUDY OF PULMONARY FUNCTIONS IN QUARRY WORKERS

BY

Dr. SINDHU.R, MBBS

DISSERTATION SUBMITTED TO

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION & RESEARCH,

TAMAKA, KOLAR, KARNATAKA

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF MEDICINE
IN
PHYSIOLOGY

Under the guidance of

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SRI DEVARAJ URS MEDICAL COLLEGE, KOLAR

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Date:

Place: Kolar *Dr. SINDHU.R.*

LIST OF ABBREVIATIONS

PFT	-	Pulmonary Function Test
TV	-	Tidal Volume
IRV	-	Inspiratory Reserve Volume
RS	-	Residual Volume
TLC	-	Total Lung Capacity
VC	-	Vital Capacity
FVC	-	Forced Vital Capacity
FEV_1	-	Forced Expiratory Volume at First Second
BTPS	-	Body Temperature and Pressure Saturated With Vapour
ISO	-	International Organization for Standardization
WHO	-	World Health Organization

ABSTRACT

Background and objectives:

Occupational lung diseases are a group of illnesses that are caused by either repeated, extended exposure or a single, severe exposure to irritating or toxic substances that leads to acute or chronic respiratory ailments. A lot of dust is generated in quarries. Very few studies have been done in Southern Indian population on quarry workers. Pulmonary function test provides an objective and quantifiable measure of lung functions and helps in early detection of lung impairment. Hence, we intended to assess the pulmonary functions in stone quarry workers and to compare with the unexposed population and to study the pulmonary function tests in correlation with duration of work in stone quarry workers.

Materials & Methods:

The study group comprised of 200 quarry workers (exposed population) and 200 unexposed populations who volunteered for the study. Pulmonary function tests which includes, FVC, FEV_1, PEFR, FEV_1/ FVC was recorded using RMS-PFT MACHINE after explaining the procedure to quarry workers and unexposed subjects. The resulting data was statistically analysed.

Results:

PFT of quarry workers was significantly reduced as compared to that of unexposed group ($p<0.001$). Lung impairment increased with increasing duration of exposure to dust in years among the quarry workers. Lung impairment was more among the loaders followed by stone grinders, drillers, blasters and stone cutters. Duration of

exposure to dust in years was found to be a risk factor for restrictive type of lung disease.

Conclusion:

PFT of quarry workers was significantly reduced as compared to that of unexposed group. Duration of exposure to dust was an independent risk factor for the decrease in PFT. Lung impairment was more among the loaders followed by stone grinders, drillers, blasters and stone cutters showing that cumulative dust exposure was a contributing factor. Smoking was a contributing factor. Respiratory questionnaire was ineffective as a screening tool to assess the lung impairment in quarry workers. PFT analysis served as a useful tool in early diagnosis of lung impairment among the quarry workers.

Key words: PFT (Pulmonary function test), Quarry workers, Restrictive lung disease.

CONTENTS

LIST OF TABLES

LIST OF GRAPHS

LIST OF FIGURES

INTRODUCTION

INTRODUCTION

Occupational lung diseases are a group of illnesses that are caused by either repeated, extended exposure or a single, severe exposure to irritating or toxic substances that leads to acute or chronic respiratory ailments. Silica is a major component of sand, rock, and mineral ores and is the second most common mineral in the earth's crust, next to feldspar. Workers in quarries are exposed to respirable dust mainly silica. Extremely high exposures are associated with much shorter latency and more rapid disease progression. Less than 10 micron size fine crystalline particle of silica goes into lungs through respiration causing respiratory impairment. The sand stone quarry worker feels difficulty in breathing while working in the quarries and the vital capacity of lungs reduces considerably. It becomes difficult to work after due course of time in sand stone quarries. Ultimately, the patient becomes unable to earn livelihood during his illnesses thus creating economic pressure on his family and he becomes a socioeconomic burden on others for his remaining life.[1]

Pulmonary function test provides an objective and quantifiable measure of lung functions. It permits an accurate and reproducible assessment of the functional state of the respiratory system and allows quantification of severity of disease. These functions depend on the integrity of the airways, pulmonary vascular system, alveolar septa, respiratory muscles and respiratory control mechanisms.[2]

Spirometry, the most frequently performed pulmonary function test (PFT), is the cornerstone of occupational respiratory evaluation programs. In the occupational health setting, spirometry plays a critical role in the primary, secondary, and tertiary prevention of workplace-related lung disease. Used for both screening and clinical evaluations,

spirometry tests are performed in a variety of venues ranging from small clinical practices to large testing facilities and multiple plant medical departments within an industry.[3]

Periodic spirometry screening of individual workers can detect breathing problems or significant changes in lung function at an early stage so that hazardous workplace exposures can be identified and eliminated to prevent or reduce occupational lung disease. Equally important, surveillance can detect changes in lung function over time among groups of workers with similar exposures and thus help to recognize serious health effects in the workplace at a time when individual results may not be severe or noticeable.

Considering the fact that quarry industry has become one of the major employers of labour as well as the means of livelihood for many people in Kolar, we therefore conducted this study to determine the prevalence of respiratory problems and impaired lung functions among quarry workers in and around Kolar. We also tried to document the availability of health care facilities and safety measures at the site as ways of minimizing occupational health hazards associated with stone quarrying.

Precautionary measures against inhalation of dust at the rock crushing sites are generally poor or nonexistent owing to lack of resources by the management of the industries and ignorance of the rock crushers. There are few reports on the effect of exposure to granite dust in exposed workers in several parts of the world.[4]

There are many quarries in and around Kolar, as there is an increasing demand of quarrying products for industrial, domestic, agricultural and other purposes to satisfy the needs of the rapidly growing population.

AIMS AND OBJECTIVES

AIMS AND OBJECTIVES OF THE STUDY

1. To assess the pulmonary functions in stone quarry workers and to compare with the unexposed population.

2. To study the pulmonary function tests in correlation with duration of work in stone quarry workers.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

A: ANATOMY OF THE LUNGS

The respiratory system is made up of a gas-exchanging organ (the lungs) and a "pump" that ventilates the lungs. The pump consists of the chest wall; the respiratory muscles, which increase and decrease the size of the thoracic cavity; the areas in the brain that control the muscles; and the tracts and nerves that connect the brain to the muscles. At rest, a normal human breathes 12 to 15 times per minute.[5]

Structure of Respiratory tract.

Upper respiratory tract: It consists of nose, Pharynx, Paranasal sinuses and Eustachian tube.

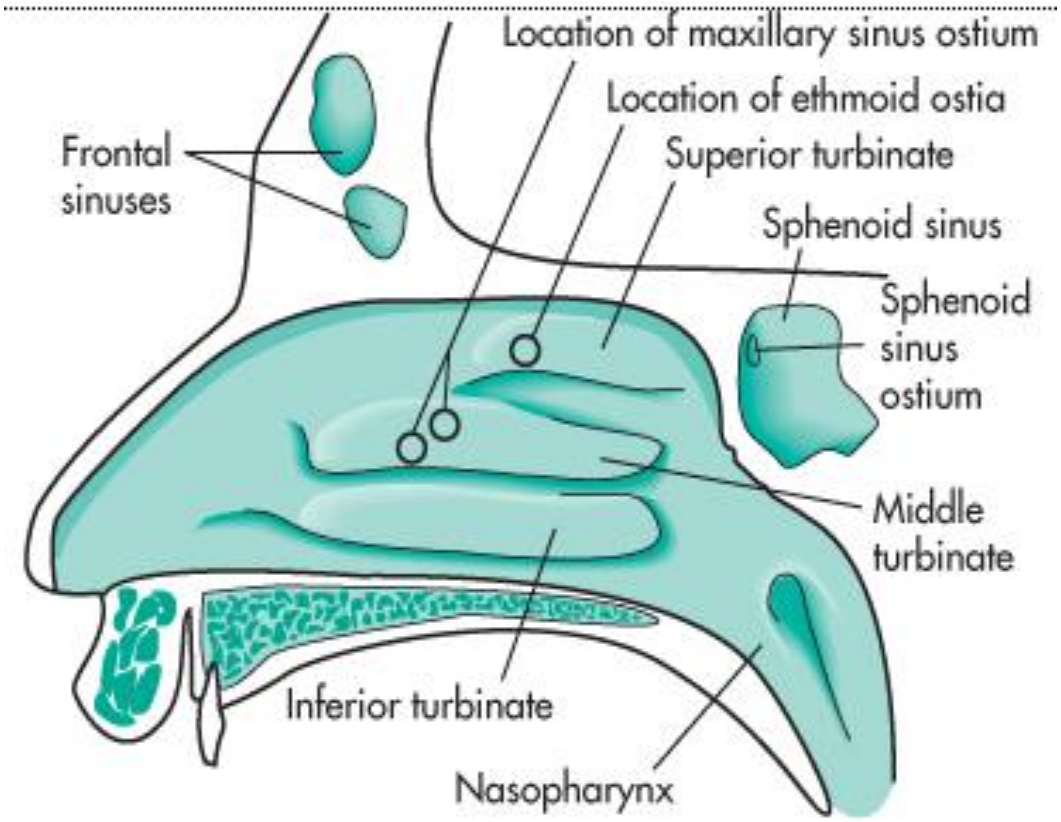
Nose: it plays a role in air conduction and conditioning, and clearance of particles and microorganisms. The mucous membrane of the nose is lined with ciliated epithelium.the cilia of the anterior part of nares, before the turbinates, beat anteriorly and propel mucous and entrapped particles towards the nostrils. From the turbinates backwards, the cilia beat so as to propel particles towards the pharynx. The structure of nose is adapted to its important function of warming and humidification of inspired air.

Pharynx: It lies behind the nasal cavities, the mouth and the Larynx, ending at the level of sixth thoracic vertebra where it is continuous with the esophagus. It is lined in the upper

part by ciliated columnar epithelium, which changes through transitional to stratified squamous epithelium over the lower part.

Paranasal sinuses and Eustachian tube

Figure 1 showing the opening of the paranasal sinuses.



Paranasal sinuses are paired maxillary sinuses, between the orbit and the molars, each having an ostium that opens into the middle meatus, between the superior and the inferior turbinates. This is lined by ciliated columnar epithelium which contains mucus glands, the cilia sweeping the mucus towards and through the ostium. Frontal sinuses, above the orbits, drains inferiorly into the middle meatus while ethmoidal and sphenoidal

sinuses superior and middle meatuses. The Eustachian tube connects the middle ear to the pharynx.[6]

Air Passages

Inspired air, after passing through the nasal passages and pharynx, where it is warmed and takes up water vapor, passes down the trachea and through the bronchioles, respiratory bronchioles, and alveolar ducts to the alveoli, where gas exchange occurs (Figure 2). Between the trachea and the alveolar sacs, the airways divide 23 times. The first 16 generations of passages form the conducting zone of the airways that transports gas from and to the exterior. They are made up of bronchi, bronchioles, and terminal bronchioles. The remaining seven generations form the transitional and respiratory zones where gas exchange occurs; they are made up of respiratory bronchioles, alveolar ducts, and alveoli. These multiple divisions greatly increase the total cross-sectional area of the airways, from 2.5 cm^2 in the trachea to 11,800 cm^2 in the alveoli. Consequently, the velocity of air flow in the small airways declines to very low values.

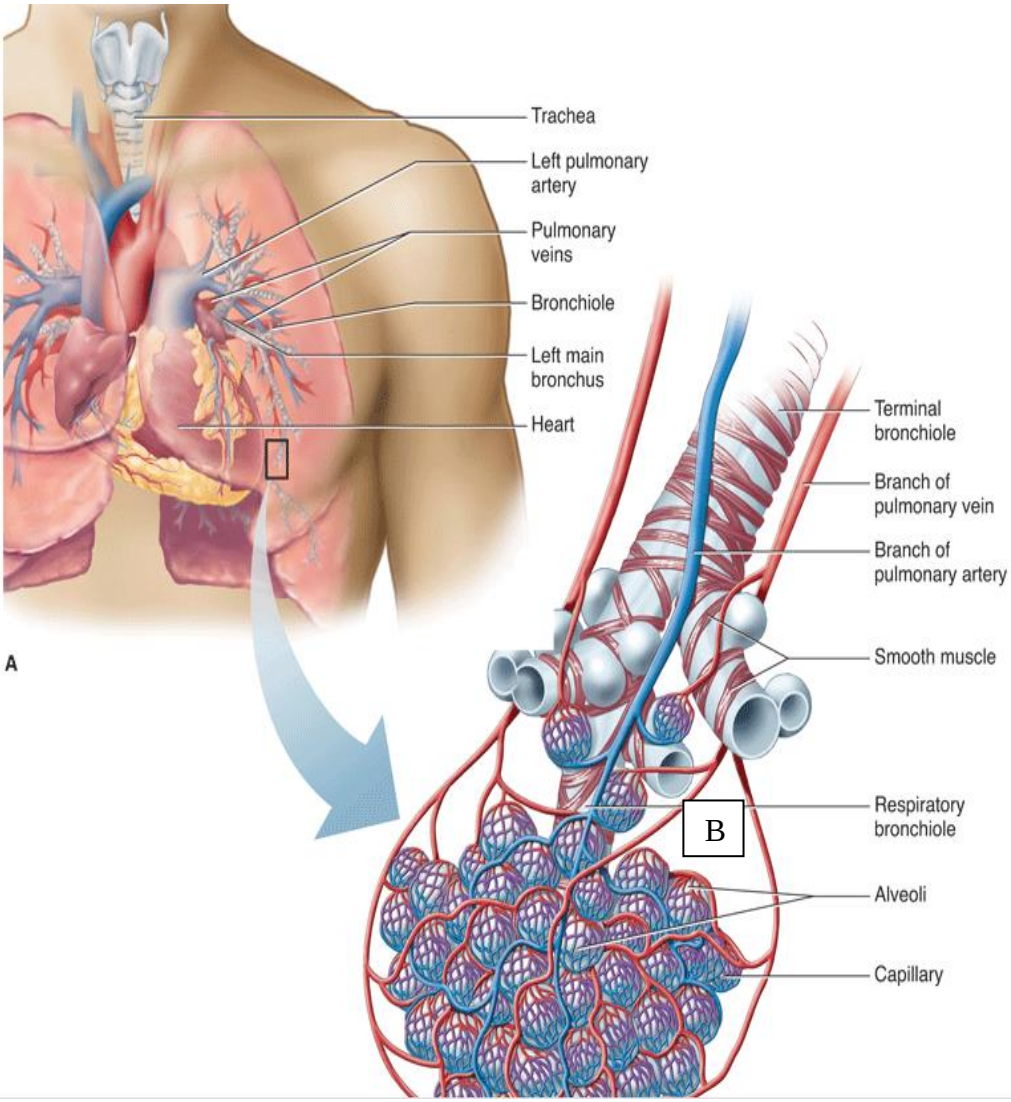
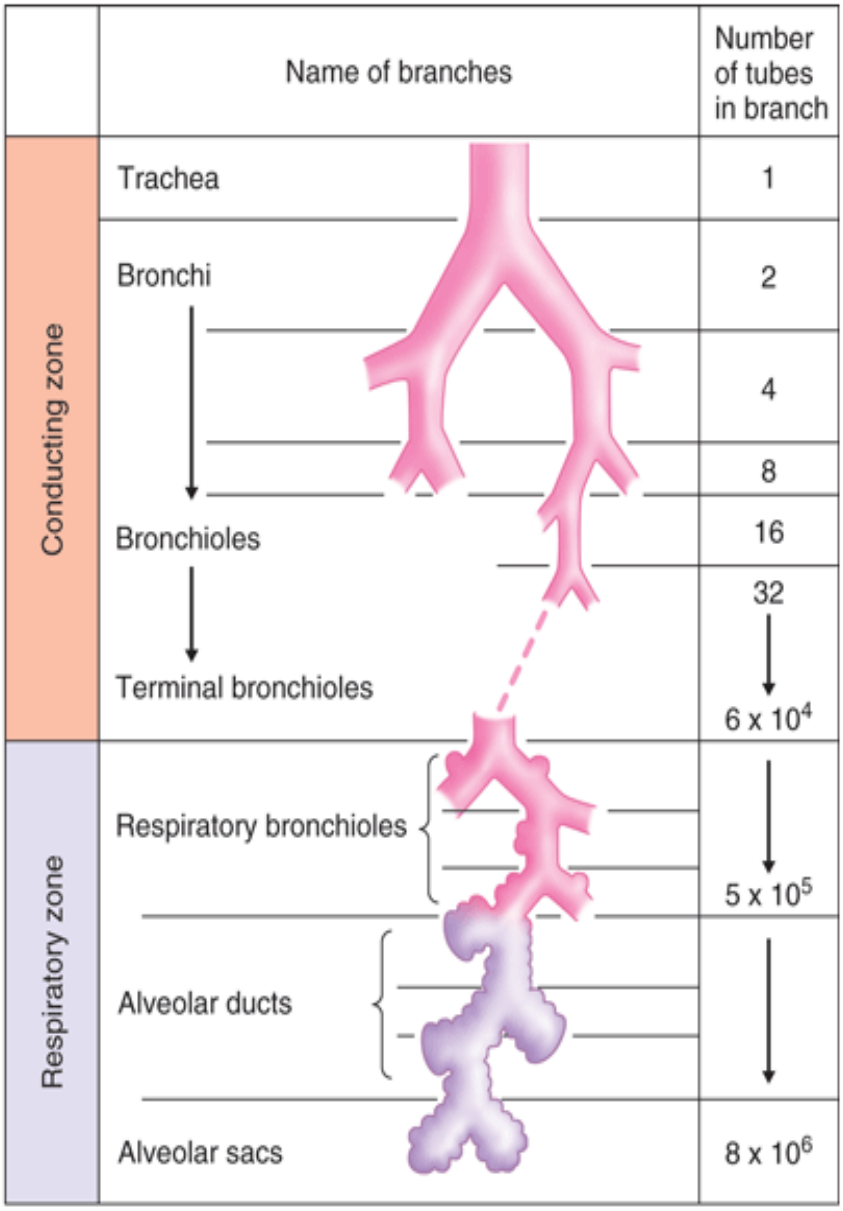


Figure 2

Structure of the respiratory system. A) The respiratory system is diagrammed with a transparent lung to emphasize the flow of air into and out of the system. B) Enlargement of boxed area from (A) shows transition from conducting airway to the respiratory airway, with emphasis on the anatomy of the alveoli. Red and blue represent oxygenated and deoxygenated blood, respectively.



C

Figure 2: (C) The branching patterns of the airway during the transition form conducting to respiratory airway are drawn (not all divisions are drawn, and drawings are not to scale).

The alveoli are surrounded by pulmonary capillaries (Figure 2). In most areas, air and blood are separated only by the alveolar epithelium and the capillary endothelium, so they are about 0.5μm apart. Humans have 300 million alveoli, and the total area of the alveolar walls in contact with capillaries in both lungs is about 70 m^2.

The alveoli are lined by two types of epithelial cells. Type I cells are flat cells with large cytoplasmic extensions and are the primary lining cells of the alveoli, covering approximately 95% of the alveolar epithelial surface area. Type II cells (granular pneumocytes) are thicker and contain numerous lamellar inclusion bodies. A primary function of these cells is to secrete surfactant; however, they are also important in alveolar repair as well as other cellular physiology. Although these cells make up approximately 5% of the surface area, they represent approximately 60% of the epithelial cells in the alveoli. The alveoli also contain other specialized cells, including pulmonary alveolar macrophages (PAMs, or AMs), lymphocytes, plasma cells, neuroendocrine cells, and mast cells. The mast cells contain heparin, various lipids, histamine, and various proteases that participate in allergic reactions.

The Bronchi & Their Innervation

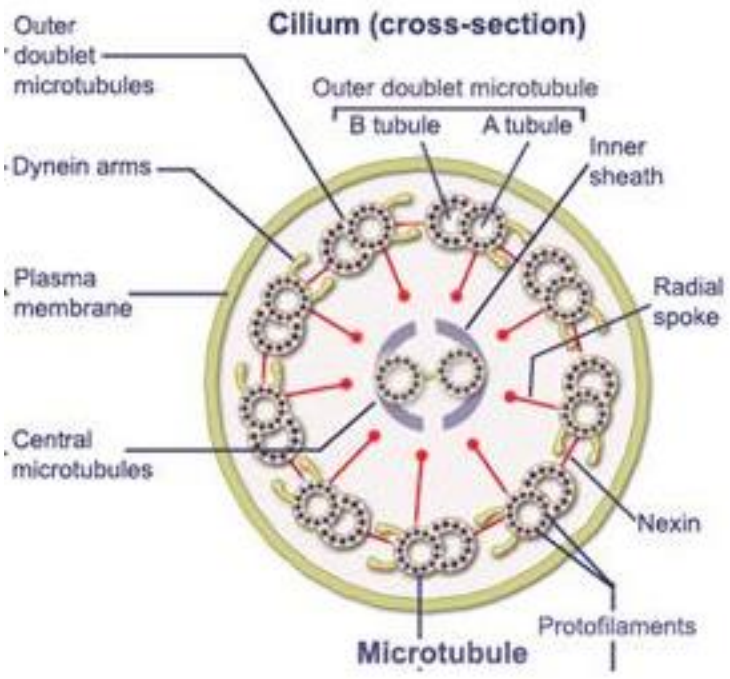
The trachea and bronchi have cartilage in their walls but relatively little smooth muscle. They are lined by a ciliated epithelium that contains mucous and serous glands. Cilia are present as far as the respiratory bronchioles, but glands are absent from the epithelium of the bronchioles and terminal bronchioles, and their walls do not contain cartilage. However, their walls contain more smooth muscle, of which the largest amount relative to the thickness of the wall is present in the terminal bronchioles.[1]

Mucosa

The ciliated cell has approximately 200 cilia, each between 5 and 10µm in length. Microvilli occur between the cilia. The epithelium contains some 1500-2000 cilia/cm^2, although the cells become more sparse in peripheral airways. The cilia beat about 1000 times per minute, always with an active stroke in the direction of the oropharynx, followed by an inactive recovery stroke. The net effect is to convey bronchial secretions towards the pharynx where they can be swallowed or coughed up.[7]

Structure of cilium.

Figure 3: showing the cross section of cilium



The shaft consists of longitudinal fibrils in a cytoplasmic matrix. There are nine paired outer fibrils and two inner ones. These fibrils are specialized protein microtubules. The peripheral nine pairs each consists of one complete and partial microtubule. Adjacent pairs are connected by nexin links, while outer fibrils are connected to the central pair by radial spokes. These linking proteins are proteins. From each of the complete outer microtubules two arms extend towards the adjacent pair. These are known as dynein arms and consist of an ATPase protein. Bending of cilium appears to result from an active sliding movement between adjacent pairs of tubules, powered by an ATP-dependent shearing force developed by the Dynein arms linking them. The short, rapidly beating cilia of bronchial epithelium are well adapted to the transport of mucus floating on a layer of watery fluid. The cilia of an individual cell beat synchronously, while there is coordination between adjacent cells in that those at right angles to the effective stroke beat synchronously and those parallel to it beat in sequence. This results in propagation of wave over the cilial surface (metachronism).

The goblet cell is responsible for the secretion of mucin. It is present in large numbers in the proximal airways and become more sparse in the peripheral bronchi and bronchioles.

The clara cell is most profuse in the bronchioles and distal bronchi. It bulges above the ciliated cells into the airway lumen and has a secretory function .[8] It has an irregular nucleus, an abundant smooth endoplasmic reticulum and mottled secretory granules at the luminal end. These cells produce surfactant-associated glycoprotein.

Basal cells are small conical cells on the basement membrane that are overlapped by the ciliated and secretory cells. They are undifferentiated cells with the potential to develop into the more specialized epithelial cells. Basal cells are found mainly in bronchi and infrequently in bronchioles.Intermediate cells are more elongated than basal cells and may reach the airway lumen. They have microvilli on their surface but have not yet acquired cilia or secretory granules. They are found equally in central and peripheral airways. Brush cells occur throughout the airways. They have a well-marked surface covering of microvilli upto 2µm in length.

Submucosa

It is a thicker layer external to basement membrane and contains elastic fibers, mainly in longitudinal bundles but also connected with the mucous membrane and with circular fibers of fibrocartilagenous layer. In addition submucosa contains mucus glands, smooth muscle, nerves and lymphatics. Mucus glands are most abundant in medium sized bronchi. Chronic airway irritation by cigarette smoke or dust results in increased number of glands and also increases in their size.

Secretions of the airway

The secretions of the airway are normally contaminated by surfactant from alveoli and by fluid transudate. The bulk is secreted by the serus and mucus cells of the bronchial glands, with important contributions from the goblet cells of the bronchial epithelium as well as from the clara cells.

Mucus is present over the bronchial epithelium as a continuous sol layer, in which the cilia beat, and a gel layer, which at bronchiolar level appears as distinct rafts floating over the sol layer; these gradually merge together to provide an almost complete covering of the epithelium in the large airways. The depth of the sol layer is about 5μm, just sufficient to cover the cilia during their effective stroke so that the gel layer is propelled over the surface. While the gel layer is clearly secreted by the mucus glands and the goblet cells, the sol layer is probably derived largely from clara cells with some contribution from transudate fluid. The watery sol layer has been shown to contain albumin, lysozyme, immunoglobulin, α_1-antitrypsin and glycoprotein, with very little lipid. The gel layer contains 95% water, protein, carbohydrate and lipid, DNa and electrolytes. The proteins are mainly complex polydispersed glycoproteins called mucins, and immunoglobulins, especially IgA. The glycoprotein of mucus has a high molecular mass, with a long protein core and carbohydrate side chains, mains ones being galactose, N-acetylglucosamine and N-acetylgalactoseamine.

The function of bronchial mucus include waterproofing, thus diminishing water loss from the respiratory tract; protection of the epithelium, by forming a barrier between it and particles in the inhaled air. Defence , by removal of inhaled particles as a result of ciliary activity, and by acting as a vehicle for immunoglobulins.

The two most characteristic physical properties of bronchial mucus are its viscosity and elasticity. In bronchial clearance, the viscosity of mucus allows the cilia to engage it during their effector stroke and to stretch it, because of its elasticity, in an

upward direction. The elastic property of the mucus allow it to transfer the energy imparted by the cilia to the transport of particles caught upon its surface.[6]

The walls of the bronchi and bronchioles are innervated by the autonomic nervous system. Muscarinic receptors are abundant, and cholinergic discharge causes bronchoconstriction. The bronchial epithelium and smooth muscle contain $_2$-adrenergic receptors. Many of these are not innervated. Some may be located on cholinergic endings, where they inhibit acetylcholine release. The β_2 receptors mediate bronchodilation. They increase bronchial secretion, while α_1 adrenergic receptors inhibit secretion. There is, in addition, a noncholinergic, nonadrenergic innervation of the bronchioles that produces bronchodilation, and evidence suggests that vasoactive intestinal polypeptide (VIP) is the mediator responsible for the dilation.

B: PULMONARY FUNCTION TESTS.

Historical Review:

129-200 AD- A Greek doctor and philosopher, Claudius Galen, performed a volumetric experiment on human ventilation. He had a boy breathe in and out of a bladder and discovered that after a period of time, the volume of gas did not change.

1681- Giovanni Alfonso Borelli attempted to measure the volume of air inspired in one breath by sucking a liquid up a tube and measuring its volume.

1718 -Jurin J. blew air into a bladder and measured the volume of air in the bladder by the principles of Archimedes. He measured 650 ml tidal volume and maximal expiration of 3610 ml.

1727-Hales St. approves the results of Jurin.

1749-Bernouilli D. describes a method of measuring an expired volume.

1788- Goldwyn E stated that the vital capacity could reach as much as 4460 ml. He corrected for temperature, but he did not use a nose-clip.

1793-Abernethy tried to determine how far expired gases had been depleted of oxygen.

1796- Menzies R. determined the tidal volume by body plethysmography.

1799- Pepys W.H. jun. found the tidal volume to be 270 ml by using two mercury gasometers and one water gasometer.

1800 -Davy H. measured his own vital capacity 3110 ml, his tidal volume 210 ml with a gasometer and the residual volume 590-600 ml by a hydrogen dilution method.

1813-Kentish E. used a simple ‘Pulmometer’ to study ventilatory volumes in disease. An

inverted bell jar standing in water, with entry at its top controlled by a tap, and graduated in pints down the side.

1831-Thrackrah C.T. describes a ‘Pulmometer’ similar to that of Kentish, but air enters the glass jar from beneath. There is still no correction for pressure, so that machine measures still not only respiratory volumes but also the power of the expiratory muscles.

1844-Maddock, A.B. publishes in the Lancet a letter to the editor about his ‘Pulmometer’. The principle of the machine was first suggested by the late Mr. Abernethy.

1845-Vierordt described some parameters like residual volume and vital capacity.

1852- Hutchinson, John publishes his paper about his water spirometer which is still used today with little alterations only. He showed the linear relationship of vital capacity to height and also showed that that vital capacity does not relate with weight at any given height.

1854-Wintrich developed a modified spirometer. He concluded that 3 parameters determine the vital capacity: body heights, weight and age.

1859-Smith E. developed a portable spirometer and tried to measure gas metabolism.

1866-Salter added the kymograph to the spirometer to record time as well as the volume obtained.

1868-Bert P. introduces the total body plethysmography

1879-Gad J. publishes a paper about the Pneumatograph and suggested a new name for his Pneumatograph as Aeroplethysmograph.

1902-Brodie T.G. was the first using a dry bellow wedge spirometer, the precursor of the still today used Fleisch spirometer.

1904-Tissot introduces a close-circuit spirometer.

1929-Knipping HW introduces a standardized method for spiroergometry.

1959-Wright BM and McKerrow CB introduced the peak flow meter.

1969-DuBois AB and van de Woestijne KP presented the whole body plethysmograph on humans.

1970- The wide spread application of microprocessors began gave way to sophisticated pulmonary testing applications.

The measurements of lung volumes and capacities are made using Spirometer.

Spirometers are available in a variety of configurations. Some spirometers primarily sense volume and are known as Volume type Spirometer, while others primarily sense air flow at particular times, which are known as Flow type Spirometers.

Flow type spirometer use pneumotachograph or rotating turbines to determine air flow.

1974-Campbell et al presents a cheap and light development of a peak flow meter.

Lung Volumes and capacities

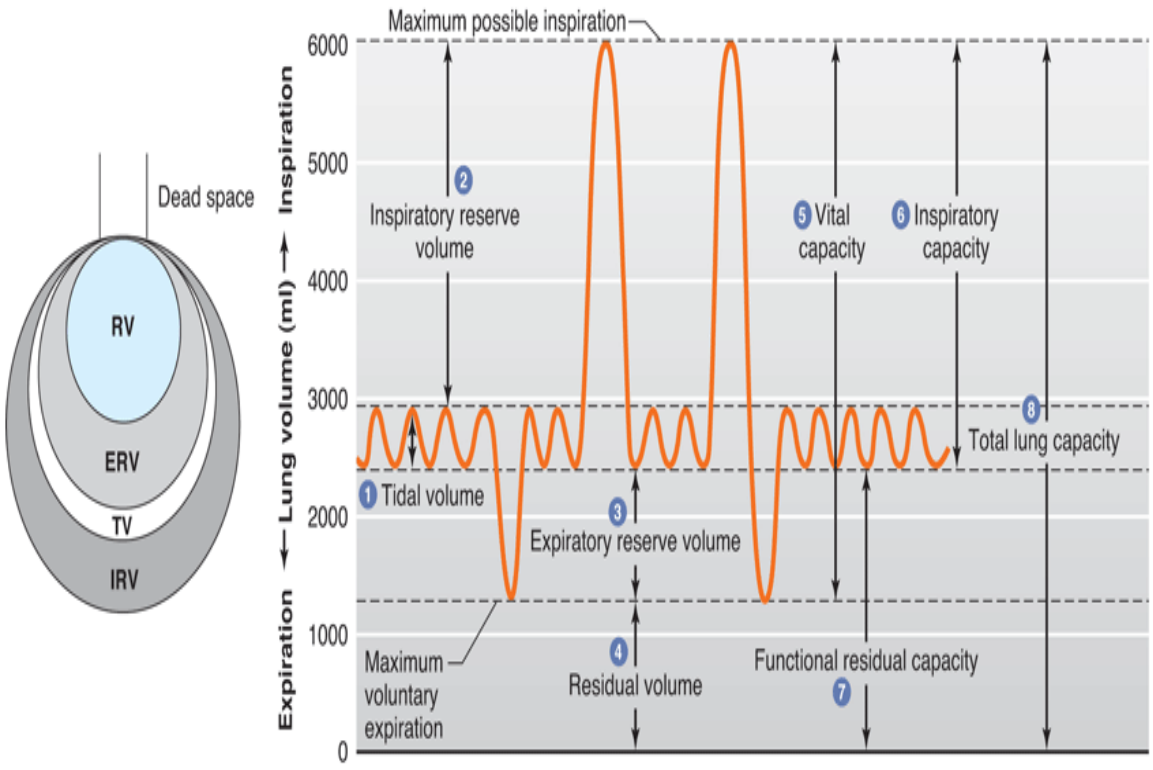


Figure4: Lung volumes and capacity measurements. Top left: A diagrammatic representation of lung space divided into lung volumes. Dead space refers to areas where gas exchange does not occur. Top right: Spirometer recordings are shown with marked lung volumes and capacities

LUNG VOLUMES	Normal values (Adults) in ml	
	Males	Females
1. Tidal volume(TV): The amount of air that moves into the lungs with each inspiration (or the amount that moves out with each expiration)	500	500
2. Inspiratory reserve volume (IRV): The air inspired with a maximal inspiratory effort in excess of the tidal volume	3300	1900
3. Expiratory reserve volume (ERV): The volume expelled by an active expiratory effort after passive expiration.	1000	700
4. Residual volume: The amount of air left in the lungs after a maximal expiratory effort.	1200	1100

LUNG CAPACITIES	Normal values (Adults) in ml	
	Males	Females
1. Inspiratory capacity: Maximum amount of air that can be inhaled after a normal tidal expiration. (TV+IRV)	3500	2200
2. Functional residual capacity: Amount of air remaining in lungs after normal tidal expiration. (RV+ERV).	2300	1800
3. Total lung capacity: Maximum amount of air the lungs can contain.(RV+VC)	5800	4200
4. Vital capacity: The amount of air that can be expired maximally after a maximal inspiratory effort.[9,10]	1200	1100

Vital capacity is a useful predictor of pulmonary diseases.[11]

Vital capacity, tidal volume, inspiratory reserve volume, expiratory reserve volume and inspiratory capacity are measured directly by simple spirometry whereas residual volume, functional residual capacity and total lung capacity can be measured by indirect methods using inert gas (like helium) dilution techniques, nitrogen washout technique and Body Pletheysmography.[5]

Spirometry is measured by different spirometers. The commonest being:

1. Simple spirometer/ student spirometer/ vitalograph.
2. Recording spirometer.
3. Wright's peak flow meter.
4. Computerised spirometer.[12]

Respiratory dead space: The space in the conducting zone of the airways occupied by gas that does not exchange with blood in the pulmonary vessels.

Pulmonary ventilation, Respiratory minute volume: The amount of air inspired per minute is normally about 6 L (500 mL/ breath x 12 breaths/min).

Dynamic lung volumes

One of the most common pulmonary function tests is spirometry, derived from the Greco-Latin term meaning "to measure breathing".

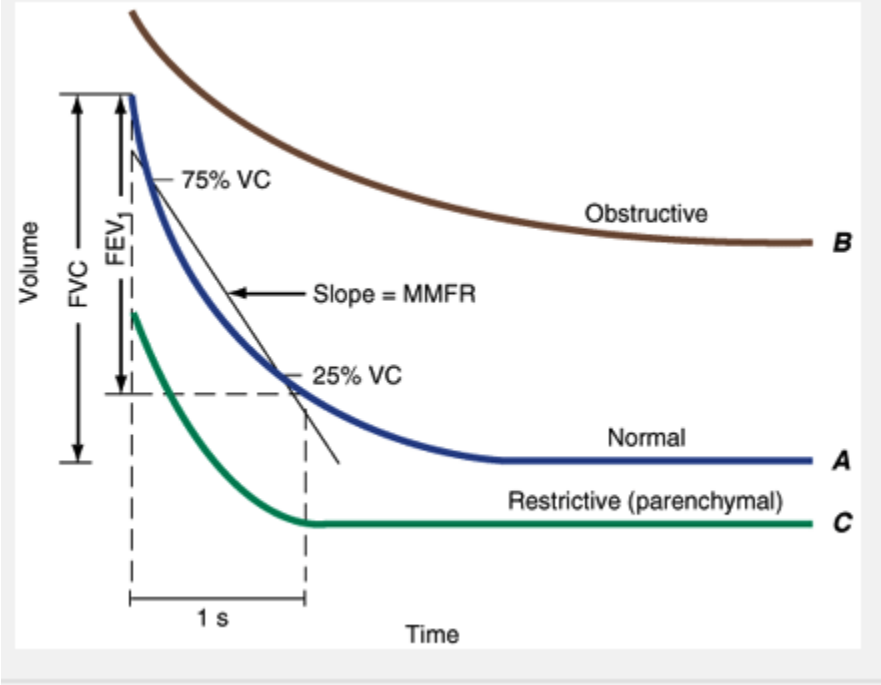


Figure 5: Spirographic tracings of forced expiration, comparing a normal tracing (A) and tracings in obstructive (B) and parenchymal restrictive (C) disease. Calculations of FVC, FEV_1, and $FEF_{25-75\%}$ are shown only for the normal tracing. Since there is no measure of absolute starting volume with spirometry, the curves are artificially positioned to show the relative starting lung volumes in the different conditions.[13]

Forced vital capacity (FVC): The largest amount of air that can be expired after a maximal inspiratory effort, is frequently measured clinically as an index of pulmonary function. It gives useful information about the strength of the respiratory muscles and other aspects of pulmonary function.

The fraction of the vital capacity expired during the first second of a forced expiration is referred to as

FEV_1 (formerly the timed vital capacity). Normal: 80%.

FEV_2: The volume of FVC expired in first 2 seconds. Normal: 95-97%

FEV_3: The volume of FVC expired in first 3 seconds. Normal: 97-100%

A spirogram is a graphical representation of bulk air movement depicted as a volume-time tracing or as a flow volume tracing. Values generated from a simple spirogram provide an important graphic and numeric data regarding the mechanical properties of the lung, including airflow FVC, FEV_1 and others.

The maneuver may be performed in a forceful manner to generate a forced vital capacity (FVC) or in a more relaxed manner to generate a slow vital capacity (SVC-the patient takes a full breath in as before but exhales slowly in their own time.). In normal person, the inspiratory vital capacity, expiratory SVC, and expiratory FVC are essentially equal. However, in patients with obstructive small airway disease, the expiratory SVC is generally higher than FVC.

Ventilatory function is measured under static conditions for determination of forced expiratory flow rates. The lung volume measurements should be corrected for body temperature and ambient pressure saturated with water vapour (BTPS).[15]

The measurement is typically expressed in liters for volumes or in liters per second for flows and is corrected for BTPS (body temperature and pressure, saturated with water vapour) of gas that is saturated with water vapour.

Ambient temperature in ^{0}C	Multiplier to convert volume to BTPS*
20	1.101
21	1.096
22	1.091
23	1.085
24	1.080
25	1.074
26	1.069
27	1.062

*Volume at ATPS(Ambient temperature and pressure saturated with water vapour) x multiplier= Volume of BTPS.[14]

By convention all Lung volumes and rates of airflow are expressed in BTPS. This enables direct comparison of pulmonary function from laboratories operating at different ambient temperature.

The FEV_1 to FVC ratio (FEV_1/FVC) is a useful tool in the diagnosis of airway disease. A decrease in FEV_1/ FVC ratio is useful in identifying obstructive lung disease and a decrease in FVC with normal or increased FEV_1/ FVC ratio suggests restrictive

lung disease. Visualizing the MEFV curve provides excellent quality control for obtaining reliable measurements of FEV_1, and FVC. Normal young adults usually complete forced expiration by 3 seconds.

	TLC	VC	FEV_1/FVC
Obstructive lung diseases	Normal or increased	Decreased or normal	Decreased
Restrictive lung diseases	Decreased	Decreased	Normal or increased

In restrictive lung diseases both FVC and FEV_1 are reduced in approximate proportion.[16]

These tests are often valuable for following the progress of a patient with chronic pulmonary disease and assessing the results of treatment.[17]

Maximal voluntary ventilation (MVV): It is the largest volume of gas that can be moved into and out of the lungs in 1 min by voluntary effort. The normal MVV is 125 to 170 L/min.

Technologies used in spirometers

Volumetric Spirometers

- Water bell
- Bellows wedge
- Rolling seal
- Dry

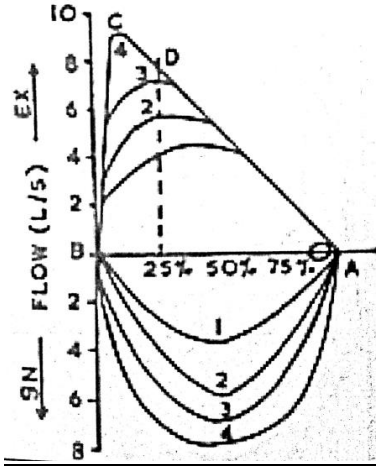
Flow measuring spirometers

- Fleisch-pneumotach
- Lilly (screen) pneumotach
- Turbine (a rotating vane, the revolutions are counted by light beam)
- Pitot tube
- Hot-wire anemometer
- Ultrasound

FVC maneuver can be displayed in two different ways:

1. Flow-volume loop
2. Spirogram

Figure6: Flow volume loop



Normal flow-volume curve with various inspiratory and expiratory efforts

A: Residual volume, B : Total lung capacity, AB : Inspiration, BA : Expiration, C : PEFR, DA : Independent expiratory effort.

Flow volume loop FVC maneuver can be recorded as instantaneous flow rate versus volume. This is flow volume loop. It can record instantaneous flow both during expiration and inspiration. It is recorded by asking the subject to take a maximal inspiration to total lung capacity (from the environment) and then to breath out as fast as possible until he can exhale no further (a maximal exhalation to residual volume), then take a rapid and deep inspiration (through the mouth piece). Flow rates above the horizontal line are expiratory flow-volume loop. Flow rates below the horizontal line are inspiratory flow-volume loop.

The highest flow rates are obtained during the first part of expiration and these are effort dependent, i.e. after approximately 1/3 (25-33%) of vital capacity. The linear part of the curve after 1/3 of expiration is called the effort independent i.e. increase in effort above a certain level will produce no further increase in flow due to the presence of dynamic compression of large airways. Effort dependent portion of the curve is primarily due to the subject's muscular effort rather than on the mechanical characteristics of the lung. The flow rates at lower lung volumes depend on the elastic recoil pressure of lungs and the resistance of the airways upstream or distal to the point at which dynamic compression occurs.[18] Changes in this portion (independent) represent changes either in the recoil pressure of the lung or in the resistance of the small airways.

The shape of the flow volume curves gives a clue whether the curves are normal or abnormal. The abnormality can be due to either obstructive or restrictive ventilatory defects. In obstructive ventilatory defect, the level of obstruction ie., intrathoracic (below 6th tracheal ring) or extrathoracic, fixed or variable and reversibility to bronchodilators

can be assessed by FV curves. In restrictive defect, the stage of disease (early or late) may be determined.

Obstructive Ventilatory Defect

a) Peripheral Obstructive Flow Volume curves are recorded in diseases such as asthma, chronic bronchitis and emphysema (Fig7).

There is a reduction in the peak flow rate but the most characteristic feature is the curvilinear shape (upward concavity) of descending limb of curve. It is probably due to abrupt emptying of large central airways associated with vigorous exhalation that causes these airways to collapse and generate a brief period of high flow. This loss of linearity is related to the severity of the obstruction as well as the type of disease.

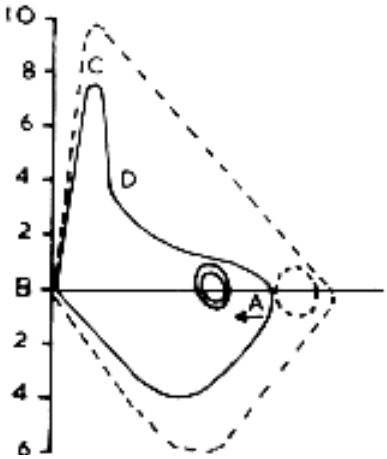


Figure 7: Flow volume curve in peripheral airways obstruction C; Reduced PEFR, CD : Period of high flow, CA : Curvi-linear shape. Arrow: Tidal volume loop moving towards vital capacity.

b) Major central obstructive flow volume curves: The inspiratory portion of the maximal flow volume curve is more sensitive to major central airways obstruction than the expiratory limb. It has great diagnostic usefulness when central airways obstruction is

suspected, a situation in which ordinary spirometry reveals a nonspecific pattern. Some cases of stridor may be mistaken for wheeze arising from within the chest and in such circumstances; the first indication towards the correct diagnosis may be obtained from the following features of FV curves.

i) Fixed upper airway obstruction (Fig8): Both the inspiratory and expiratory limbs are truncated. The shape is quite characteristic with more or less equal restriction of both inspiratory and expiratory flow rates.

ii) Intrathoracic variable obstruction (Fig8): Obstruction at expiration. Expiratory limb is flattened and inspiratory limb is normal.

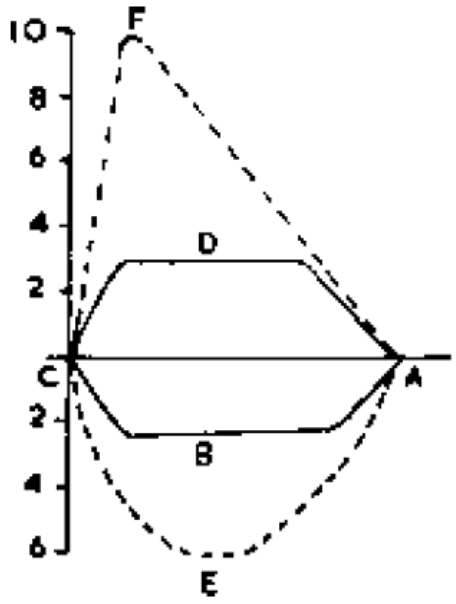


Figure 8: Flow volume curves In central airways obstruction: Curve ABC - CDA = Fixed obstruction Curve AEC - CDA = Intrathoracic variable obstruction Curve ABC - CFA = Extrathoracic variable obstruction

iii) Extra thoracic variable obstruction (Fig8): Obstruction at inspiratory phase. Inspiratory limb is flattened and expiratory limb is normal.

Restrictive Ventilatory Defect

Any disease which decreases the lung expansion either by chest wall diseases or by space occupying lesion in the pleural cavity or lung causes restrictive type of abnormality.

The Fig 9 shows the restrictive type where curve 'C' is normal. In early interstitial lung disease (curve a) even before lung volumes are decreased, the FV curves usually show super maximal expiratory airflow associated with a steep descending limb of the curve (due to increase in lung elastic recoil) and the curve becomes tall and narrow or vertically oriented with respect to the volume axis. In severe reduction of lung volumes (curve b), the FV curve may maintain a relatively normal shape but appears miniatured in all directions.

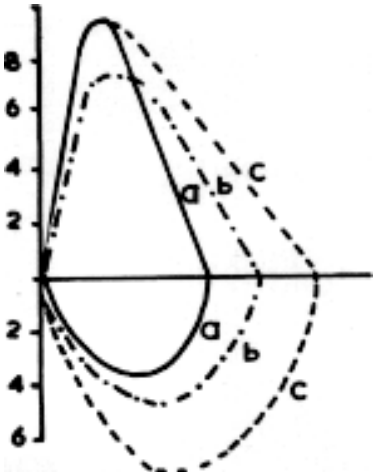


Figure 9: Flow volume curve in restrictive airways disease a : early stage of restrictive type, b : late stage of restrictive type, c: normal curve

Shape of FV curves gives extremely useful information with regard to in identification of the cause of airway obstruction and detection of early changes.[19]

Flow-volume loop yields the following main pulmonary function tests data:

1. FEV_1
2. FVC
3. Peak expiratory flow rate (PEFR): It is the maximum flow rate achieved during the maneuver measured in L/min or L/sec. Normal- 500 L/min. Peak flow is largely a function of the large airway caliber. It greatly depends on expiratory muscle strength and the patient's effort and co-ordination. It is highly effort dependent and hence many clinicians use PEFR in addition to FVC and FEV_1.
4. Forced expiratory flow 50% is the volume achieved after exhaling 50% of the total FVC.
5. Forced expiratory flow 25-75% or average mid expiratory flow (MMEF) is the average flow rate over the middle section of the vital capacity and is calculated from the spirogram by dividing the vital capacity into quarters, drawing a line from the first (25%) and third (75%) quartiles. This indicates the patency of small airways.
6. FEV_1/FVC ratio: expressed in percentage of FVC

   FEV_1/FVC > 70%- Normal.[20]

   <70% - Mild obstruction

   <60% - Moderate obstruction

   <50% - Severe obstruction

C: EFFECTS OF RESPIRABLE DUST (SILICA) ON RESPIRATORY SYSTEM.

Occupational exposures to respirable crystalline silica occur in a variety of industries and occupations because of its extremely common natural occurrence and the wide uses of material and products that contain it. Silica refers to the chemical compound silicon dioxide (SiO2), which occurs in a crystalline or non-crystalline (amorphous) form. Crystalline silica may be found in more than one form (polymorphism). The polymorphic forms of crystalline silica are alpha quartz, beta quartz, tridymite, cristobalite, keatite, coesite, stishovite, and moganite. Each polymorph is unique in its spacing, lattice structure, and angular relationship of the atoms. In nature, the alpha (or low) form of quartz is the most common. This form is so abundant that the term quartz is often used in place of the general term crystalline silica. Quartz is a common component of soil and rocks; consequently, workers are potentially exposed to quartz dust in many occupations and industries. Occupational exposure to respirable crystalline silica is a serious but preventable health hazard.[21]

According to the International Standardization Organization (ISO 4225 - ISO, 1994), "Dust is defined as small solid particles, conventionally taken as those particles below 75µm in diameter, which settle out under their own weight but which may remain suspended for some time".[22] According to the "Glossary of Atmospheric Chemistry Terms" (IUPAC, 1990), "Dust is Small, dry, solid particles projected into the air by natural forces, such as wind, volcanic eruption, and by mechanical or man-made processes such as crushing, grinding, milling, drilling, demolition, shovelling, conveying, screening, bagging, and sweeping. Dust particles are usually in the size range from about

1 to 100μm in diameter, and they settle slowly under the influence of gravity."[23] It is considered that dusts are solid particles, ranging in size from below 1μm up to at least 100 μm, which may be or become airborne, depending on their origin, physical characteristics and ambient condition.

Penetration and deposition of particles in the human respiratory tract

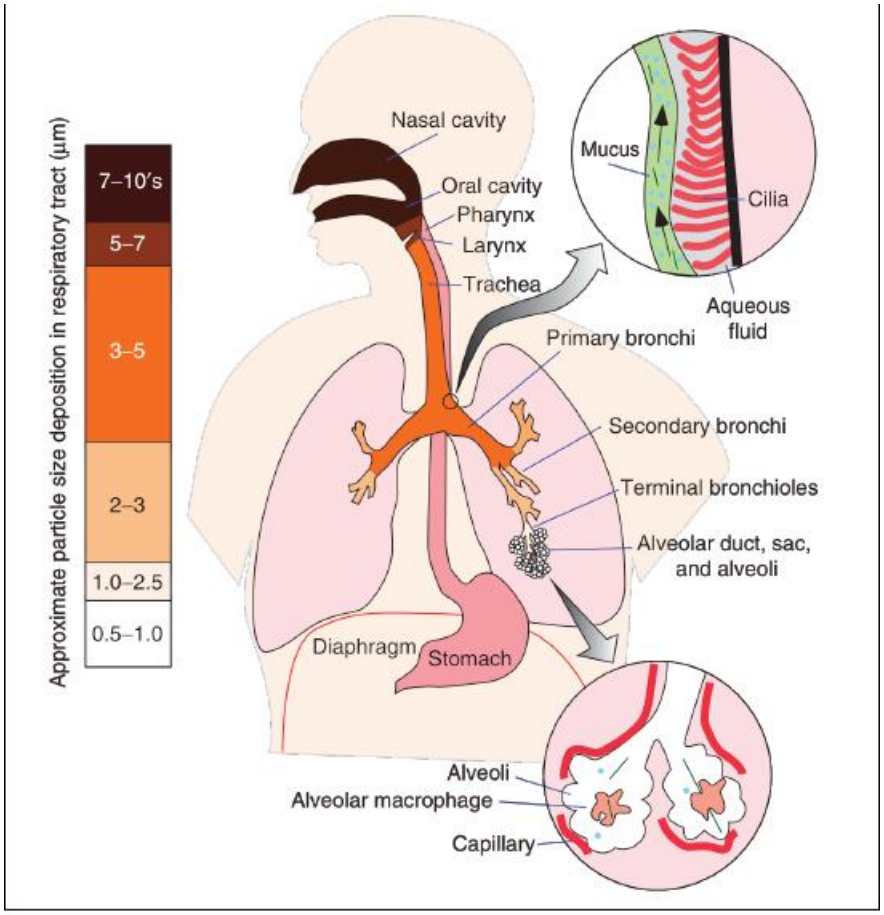
Particles small enough to stay airborne may be inhaled through the nose (nasal route) or the mouth (oral route). The probability of inhalation depends on particle aerodynamic diameter, air movement round the body, and breathing rate. The inhaled particles may then either be deposited or exhaled again, depending on a whole range of physiological and particle-related factors. The five deposition mechanisms are sedimentation, inertial impaction, diffusion (significant only for very small particles < 0.5μm), interception, and electrostatic deposition. Sedimentation and impaction are the most important mechanisms in relation to inhaled airborne dust, and these processes are governed by particle aerodynamic diameter. There are big differences between individuals in the amount deposited in different regions.[24, 25]

The largest inhaled particles, with aerodynamic diameter greater than about 30 μm, are deposited in the air passages between the point of entry at the lips or nares and the larynx. During nasal breathing, particles are deposited in the nose by filtration by the nasal hairs and impaction where the airflow changes direction. Retention after deposition is helped by mucus, which lines the nose. In most cases, the nasal route is a more efficient particle filter than the oral, especially at low and moderate flow rates. Thus, people who normally breathe part or all of the time through the mouth may be expected

to have more particles reaching the lung and depositing there than those who breathe entirely through the nose. During exertion, the flow resistance of the nasal passages causes a shift to mouth breathing in almost all people. Other factors influencing the deposition and retention of particles include cigarette smoking and lung disease.

Of the particles which fail to deposit in the air passages between the point of entry at the lips or nares and the larynx, the larger ones will deposit in the tracheobronchial airway region and may later be eliminated by mucociliary clearance or - if soluble - may enter the body by dissolution. Inhaled mineral dust with an aerodynamic diameter bigger than 10 µm, stops in the upper respiratory tract where the particles get trapped in the mucous lining of the nasopharyngeal tract. They are normally of an only small health concern, unless the particles are of toxic mineralogy. If the dust particles have an aerodynamic diameter smaller than 10 µm, they can penetrate more deeply into the lung passages to the tracheobronchial regions, where they also get trapped in a layer of mucus.[26] In aerodynamic diameter terms, only about 1% of 10-µm particles gets as far as the alveolar region, so 10 µm is usually considered the practical upper size limit for penetration to this region. Particles $\leq$ 4.0 µm are defined as respirable dust and those particles are small enough to even reach the gas-exchange region of the lung, the alveoli.[27] Material-specific factors of a particle, like size, shape, charge and relative weight, host factors, like air speed, diameter of the airways and health status determine where a particle is deposited in the respiratory tract.

Figure 10: Figure showing approximate particle size deposition in respiratory tract.



Clearance of particles from the respiratory tract

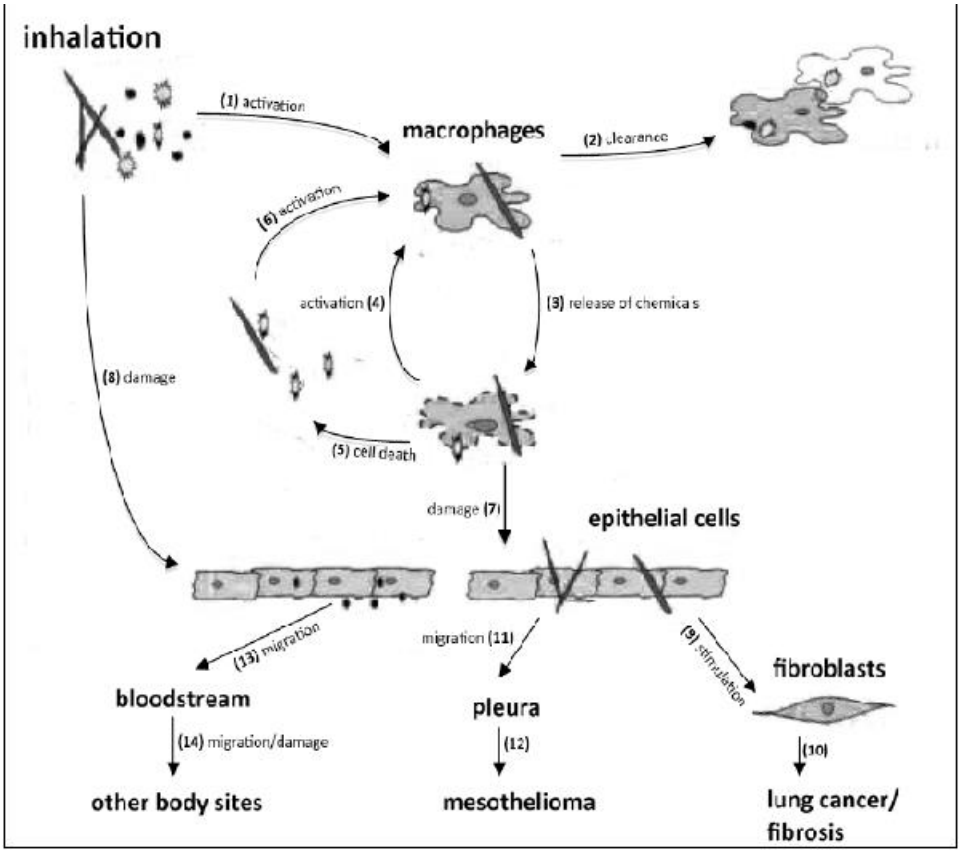
After deposition, the subsequent fate of insoluble particles depends on a number of factors. Soluble particles depositing anywhere may dissolve, releasing potentially harmful material to the body. In the nose and airways an active epithelium protected with a viscous layer of mucus, acts as a barrier to prevent damage from entered particles. In the alveoli the barrier between the alveolar wall and the capillaries is only very thin, to allow an intense air-blood contact for gas exchange. This and the large surface area make the alveoli more vulnerable to environmental particles than the nose and airways.[28]

As mineral particles get into the respiratory tract, the body tries to clear them.

- The bigger particle which gets trapped in the mucus of the nasopharyngeal tract, are cleared by sneezing, blowing, dripping through the nose or by flow into the pharynx where they may be swallowed.

- The particles, which are deposited in the mucus of the tracheobronchial region are cleared to some extent by coughing and to another extent by the movement of ciliated cells in this region. The cilia are in continuous and synchronized motion, which causes the mucous layer to have a continuous upward movement, reaching a speed in the trachea of 5-10 mm per minute. Insoluble particles deposited on the ciliated epithelium are moved towards the epiglottis, and then swallowed or spat out within a relatively short time.[28]This process is called mucociliary escalator and is dominating the clearance of particles from the nose and airways. It is interesting to note that the rate of clearance by the mucociliary mechanism may be significantly impaired by exposure to cigarette smoke.
- The smallest particels ($\leq$ 4.0 μm), which are of main interest, are grouped by Fubini and Fenoglio (2007) into three groups: micron-sized mineral particles, mineral fibers and nanoparticles. Those groups induce to some extent different clearance mechanism, but all are cleared predominantly by macrophage phagocytosis.

Figure 11: Pathology of inhaled silica dust.



1. The micron-sized mineral particles, which settled in the pulmonary alveoli, are cleared by different modes. Foreign substances in the human body lead to the activation of macrophages, in the case of particles in the alveoli it leads to the activation of alveolar macrophages (mononuclear phagocytes in the lung alveoli). The activated macrophages ingest the particles. As they contain lysosomes with acidic pH and digestive enzymes, they can degrade and clear the particles. They also release chemicals to activate other macrophages. Alveolar macrophages have a life span of about 50 days in average. When they eventually die, they release their contents, which consist of already engulfed particles and many substances of which some lead to the recruitment of new macrophages. Those then again re-ingest the dying macrophages released particles. This

cycle of cell death and newly recruited cells in the alveoli can lead to increased inflammation, lower rate of particle clearance and a reduced capacity of the lung to perform gas exchange.[29] An increased particle load in the alveoli can have the same effect, due to a high dose of inhaled particles. This exceeds the phagocytotic capacity of the alveolar macrophages, their efficiency in particle uptake decreases and thus the particle burden in the alveoli increases. As long as particles exist in the alveoli, the inflammation will last. The cytokines, growth factors, and reactive oxygen species, which are released by the dying macrophages, can directly damage the cells in the alveoli. With a diameter of 10 µm, macrophages are able to ingest particles up to a diameter of 5 µm. If particles are larger than 5 µm macrophages are not able to ingest them fully, but as the particles penetrate the plasma membrane of the macrophages, lysosomal fluids and enzymes can flow out and in turn lead to the activation of new macrophages or lead to the damage of surrounding cells. [29]

Another process for the clearance of micron-sized mineral particles is dissolution in the fluid lining the alveoli. Particles can get to some extent or entirely dissolved over time. Especially particles composed of mainly calcium carbonate and some other metal carbonates, like limestone, marble or dolomite easily get dissolved in the acidic pH of the lysosomal fluids and enzymes released by alveolar macrophages. The dissoluted particles can be retained by the mucus or absorbed into the body through the epithelium of the respiratory tract. Not all of the particles in the alveoli get degraded by the macrophages or dissolved, but some remain as free mineral particles in the alveoli. While some of the remaining mineral particles induce no harm, others can damage the epithelial cells and by this stimulate fibroblastic cells. Fibroblastic cells can lead to the deposition of collagen, a

protein which is needed in the white fibers of skin, in the cartilage and the connective tissue. If those processes go on for some time, it might result in the development of lung cancer or fibrosis. The detection of fibrosis in the lung by radiograph may work only after years of ongoing fibrosis.[29]

2. The second group, the mineral fibers, induce almost the same reactions in the body as explained above, though their case is a little more complex. They can be from a few micrometers up to several hundred micrometers long, while their diameter is just a few tenths of a micrometer. If the fibers are short, they get easily enfolded and ingested by macrophages, but if they are long the macrophages are not able to engulf them and they remain in the alveoli. As described before they can damage the surrounding cells and macrophages. The long, thin and rigid fibers are even able to cause mesothelioma, a fatal neoplasia (abnormal proliferation of cells) of pleural mesothelial cells(membrane that covers the lung), because they may migrate to the pleura.[29]

3. The third group, the nanoparticles induce a different reaction in the body. The small size of the nanoparticles hinders the clearance by macrophages, leading to a higher burden of them in the alveoli. Because they are so small, some are able to migrate through the surrounding cells (alveolar membrane) and get into the interstitial lung tissue. They can remain there or migrate further on, to the lymphatic system. Normally, most of those particles get filtered in the lymph nodes and remain there. Still some get via the lymph into the bloodstream. On this way they can get away from the lung, reach other organs and possibly cause some harm at other sites in the body than the lung (Fubini and Fenoglio, 2007). The degree of toxicity of nanoparticles is not totally clear yet. Some studies have shown that at a certain mass they can result in greater inflammation than

bigger particles. It is assumed that this is due to the high surface area, the large amount of reactive "edge" and "corner" sites of the small particles. This inhibits phagocytosis, enhances oxidative stress, enhances inflammation in the lung epithelium and permits the ultrafine particles to diffuse more readily into the lung interstitium. There is also some evidence that nanoparticles are not in all circumstances more toxic than bigger particles.[28]

Risk to health

Wherever the particles are deposited, either in the upper respiratory tract or in the lung, they have the potential to cause harm either locally or subsequently elsewhere in the body. Particles that remain for a long time have increased potential to cause disease. This is why inhaled particles are important in relation to environmental evaluation and control. Health effects, which may result from exposure to different types of dust, include pneumoconiosis, cancer, systemic poisoning, hard metal disease, irritation and inflammatory lung injuries, allergic responses (including asthma and extrinsic allergic alveolitis), infection, and effects on the skin.[28] Silicosis, asbestosis and coal workers' pneumoconiosis (CWP) are the best known diseases caused by the mineral dusts.

Occupational exposure to dust is a well-known phenomenon, especially in developing countries.[30,31] Although sources of air pollutants include power plants, cement factories, refineries and petrochemical industries, the emission of particulates is quite high from quarries.[32] Cutting, breaking, crushing, drilling, grinding or abrasive blasting of the stone may produce fine silica dust. Production process of most factory-made products is harmful to our health and environment. Silica is the most important stone used in stone cutting factories.[33] Rotary drill operators, front-end loader operators, truck drivers, and crusher operators are permanently exposed to stone dust.[34] The health impacts of working

in stone quarrying industry have been documented in very few studies.[35,36] Few epidemiological studies have supported the association between respiratory impairment and occupational exposure to dust.[35] Again, individuals working in dusty environment have been found to carry the risk of inhaling particulate materials (e.g., silica) that may lead to adverse respiratory effects, such as chronic bronchitis, emphysema, acute and chronic silicosis and lung cancer which are disabling and can even be fatal.[37,38,39]

Also, high prevalence of silicosis has been reported among workers engaged in quarrying shale sedimentary rock in India. Prevalence of restrictive lung disease is high among stone cutters.[33] According to Urom, the major respiratory symptoms among quarry workers include non-productive cough, chest pain, catarrh and dyspnea.[4] Considerable pulmonary function impairments have been reported in quarry workers.[40,41]

In recent years various groups of investigators have studied the epidemiology of chronic respiratory disease both in industry and in the general population. In most of these surveys questionaries, completed by interviewers, have been used to establish the prevalence of common respiratory symptoms, in particular those associated with chronic bronchitis.[42]A Questionnaire based study and health records obtained from the health facilities in the communities revealed notable deteriorations in the health of the people as a result of the quarrying activities and exposure of particulate matter (dust). Air pollution due to quarry dust is very high during the dry season as dust concentration is higher.[43]

Silicosis

Silicosis is a fibrotic disease of the lungs due to inhalation of crystalline silicon dioxide, usually in the form of quartz. Such a disease has occurred in metal miners and masons

since ancient times, but assumed particular importance in the cutlery and pottery trades in the nineteenth century. Silicosis may affect anyone involved in quarrying, carving, mining, tunnelling, grinding, or sandblasting, if the dust generated contains quartz.

Silicosis occurs in three forms: acute form, accelerated form and chronic form.

Aetiology and pathology

Crystalline silica is present in the earth's crust usually as quartz, although other forms such as crystobalite and tridymite occur occasionally. All are extremely toxic to macrophages. Quartz seems to be most toxic when freshly fractured, suggesting that surface properties are important in toxicity. This concept is supported by experimental evidence that various clay minerals and other chemicals which occlude the surface reduce the toxicity of inhaled quartz when inhaled simultaneously in mixtures of dust. The quartz content of dust from different types of stone may vary considerably from some sandstone which is 100 per cent quartz to shales and slates which may contain less than 10 per cent.

Inhaled particles of quartz small enough (generally less than 7 μm aerodynamic diameter) to reach the acinus are engulfed by macrophages and cause disruption of the phagosome, probably by peroxidation of membrane lipids. Before macrophage death, other reactions occur leading to release of inflammatory mediators, includingIL-1, various growth factors, tumour necrosis factor, and fibronectin, largely from interstitial rather than alveolar macrophages. Silica is probably transported across the alveolar epithelium by migrating macrophages and by endocytosis by type 1 alveolar cells, and it is clear from the distribution of pathological lesions that quartz is transported widely in the lung via lymphatics, much of it ultimately being deposited in hilar nodes, which it destroys. This

destruction of the nodes is very likely to be responsible for blockage of the exit route for further inhaled dust, and therefore for its retention in the lung and the developmnent of progressive massive fibrosis or, rarely, accelerated or even acute silicosis.

Macroscopic inspection of silicotic lungs shows fibrous pleural adhesions, enlarged lymph nodes that contain fibrotic, often calcified, nodules, and grey nodules throughout the lung. These nodules vary from a few millimetres to several centimetres in diameter and are more profuse in the upper zones. They may be calcified, and they have a typical whorled appearance when cut across. The largest lesions consist of many such nodules that have become confluent, and, as in coal-worker's pneumoconiosis, this progressive massive fibrosis may undergo ischaemic necrosis and cavitate.

Under the microscope the silicotic nodule consists of concentric layers of collagen surrounded by a zone of doubly refractile silica particles, macrophages, and fibroblasts. The nodule may contain the remnants of the respiratory bronchiole and arteriole, destroyed by fibrosis. The mechanisms responsible are destruction of macrophages leading to inflammation and laying down of collagen, release of the quartz, further macrophage attraction, and repetition of the cycle. This presumably occurs first in nodes on the drainage pathway, and as these become progressively blocked the process is repeated in the lung. As the quartz never gets removed thereafter, the process continues indefinitely and severity of disease depends on the mass inhaled and retained.[16]

Pathological varieties of silicosis include simple (nodular) silicosis, progressive massive fibrosis, silicoproteinosis (acute silicosis) and diffuse interstitial fibrosis.

A study showed that patients who were exposed by dry-cutting a relatively new, artificial, decorative stone product with high crystalline silica content, had moderate-to-

severe restrictive lung disease, few of them developed acute silicosis and few deaths were also reported. The patients all reported that their work was performed without dust suppression (e.g., wet as opposed to dry cutting or effective local ventilation), typically working without any personal respiratory protection, an average of 10 to 12 hours daily. They were not aware of any industrial hygiene measurements or other assessments having been carried out by governmental inspectors at the workplace, thus there was no data quantifying the airborne dust concentrations that occurred.[44] The Turkish quarry and construction workers who were exposed to silica dust were found to develop lung cancer. It was also seen that smoking is a potential threat for the development of lung cancer among those exposed to silica dust.[45]Studies have revealed high morbidity and mortality among stone workers of Shakarpur due to silicosis. Besides the fatal disease, the workers also suffer from debilitating co-morbidities especially tuberculosis and under nutrition.[46] For workers in workplaces with high dust levels, administrative measures can also be used to reduce exposure to silica dust e.g., by cutting short their working hours or job rotation. Exposure control at the worker level includes training and education on work practices, and personal protection. Personal protection equipment such as respirators is a good solution for short duration tasks. Regular medical evaluation may detect adverse health effects among exposed workers before disease reaches advance stages. Medical evaluation commonly includes respiratory questionnaires, physical examination, and spirometry.[47]

METHODOLOGY

MATERIALS AND METHODS

SOURCE OF DATA

The study group comprised of 200 quarry workers (exposed population) and 200 unexposed populations who volunteered for the study.

SELECTION OF SUBJECTS

Ethical clearance for the study was obtained from the Institutional Ethical Committee. The exposed population was recruited based on various inclusion and exclusion criteria from quarries in and around Kolar after taking written informed consent.

CRITERIA FOR SELECTION OF STUDY GROUP

Inclusion criteria :

Exposed group:

1. Male subjects between 18-40yrs of age.

Unexposed group:

1. Male subjects between 18-40yrs of age.

Exclusion criteria:

Based on history and clinical examination subjects with

1. Kyphoscoliosis
2. Neuromuscular disorders like Myasthenia gravis.
3. Peripheral nerve disorder.

The quarry workers were categorized based on their work as Blasters, drillers, loaders, supervisors, stone cutters and stone grinders.

STONE GRINDING UNIT

LOADING

STONE CUTTER

STONE CUTTING UNIT

STUDY DESIGN: Cross sectional study

STUDY PERIOD: December 2011 to December 2012

SAMPLE SIZE ESTIMATION:

Anticipated population proportion: 50%, 50%

Confidence interval is at 95%

Absolute precision is at 10% points

Intermediate value of 0.5

V=0.05, d=0.1, n= 193 in each arm (200 exposed and 200 unexposed)

$n= Z^2_1 - \alpha/2 [P_1 (1-P_1) + P_2 (1-P_2)] / d^2$

or

$n= Z^2_1 - \alpha/2 V/d^2$ where, $V= P_1 (1-P_1) + P_2 (1-P_2)$

METHODOLOGY

After taking informed consent of the subjects, information was collected about demographic characteristics like sex, age, height and weight and a modified prevalidated respiratory questionnaire was given to both quarry workers and unexposed group.

SPIROMETRY

Pre- requistes for Spirometry:

- The individual was enquired about potential contraindications for spirometry such as haemoptysis, recent history of surgery and present history of acute illness that might alter the test validity and reliability.
- History regarding consumption of alcohol or strenuous exercise within the preceding hour was enquired. Individual with affirmative response to any of the above were requested to avoid alcohol and exercise for 24hours and then the test

was done the next day.

- Before starting the lung function tests, the subjects were asked to loosen tight clothing if any.
- The study was conducted at the same time of all the days to rule out diurnal variation.

The instrument used in this study was portable PFT system RMS-MEDSPIROR.

Recording:

Spirometry was performed after demonstration of the required procedure. The subject was asked to take deep inspiration from environment followed by forceful expiration into the mouth piece of the MEDSPIROR in standing posture. The mouthpiece was required to be inserted without leak of air or obstruction by the lips or teeth and forced expiration continued to completion without a pause and without leak of air around the mouthpiece. Individuals were asked to repeat the procedure three times and the best one was printed out.

All the lung volumes and capacities obtained (FVC, FEV_1, PEFR and FEV_1/FVC ratio) were expressed with correction for body temperature at the ambient pressure, saturate with water vapour (BTPS).

PULMONARY FUNCTION TEST MACHINE- RMS- MEDSPIROR

RECORDING OF PULMONARY FUNCTION TEST

RESULTS AND ANALYSIS

RESULTS & ANALYSIS

In the present study, 200 quarry workers (Exposed population) and 200 unexposed gender matched controls were selected considering the inclusion and exclusion criteria and were subjected to pulmonary function test recordings. The data was analysed using appropriate statistical methods and discussed below.

Presentation of data:

Master chart showing age, height, weight, FVC, FEV_1, PEFR, FEV_1/FVC ratio, pack years of smoking of the exposed population and unexposed population, duration of exposure in years and category of occupation among exposed population.

Statistical Treatment of the data:

The data was suitably arranged into tables for discussion under different headings. Descriptive statistical analysis was carried out on this data. Results on continuous measurements are presented as mean $\pm$ standard deviation and results on categorical measurements are presented in number%. Significance was assessed at 5% level of significance. To compare the differences between the mean spirometric values (FVC, FEV_1, PEFR, FEV_1/FVC ratio)of exposed and unexposed age matched controls independent student't' test was employed.[48,49] The level of significance was fixed at p=0.05.

To estimate the relationship quantitatively between two variables namely, duration of exposure in years and various spirometric parameters Pearson's correlation co-efficient was estimated.[4] Comparison of Duration of occupation in years of three groups studied (1-5 years, 5-10 years and >10 years) among the exposed population as well as the comparison of the pulmonary function parameters among the various

categories of exposed population was done using by ANOVA test.[50] Post Hoc Bonferroni test was done to know which category was affected most in comparison with other categories. Linear regression as well as multiple regression analysis was done as smoking and height are confounding factors. [51]

Conclusions are drawn based on the outcome of this statistical treatment.

RESULTS AND ANALYSIS:

4.5% of the quarry workers complained of cough, sputum production and breathlessness.

Table 1: Comparison of Age, Height, Weight and BMI in exposed and unexposed groups studied

	Exposed population	**Unexposed population**	**P value**
Age in years	29.01±5.13	29.16±5.07	0.769
Height (cm)	167.05±6.85	169.17±7.82	0.004*
Weight (kg)	65.14±9.77	67.53±11.07	0.023*
BMI(kg/m^2)	23.38±3.53	23.56±3.34	0.591

* Statistically significant

There was no statistical significance for age between exposed and unexposed groups. Mean BMI is similar in two groups and a significant difference in height and weight was observed among the two groups.

Table 2: Comparison of pulmonary function test in exposed and unexposed groups studied.

PULMONARY FUNCTION TEST	**EXPOSED POPULATION (n=200)**	**UNEXPOSED POPULATION (n=200)**	**P value**
FVC(L)	2.27±0.49	3.24±0.46	<0.001**
FEV_1(L)	1.99±0.54	3.05±0.54	<0.001**
PEFR(L/S)	4.92±2.24	8.13±1.48	<0.001**
FEV_1/FVC%	88.77±19.29	93.26±6.58	0.002*

* Statistically significant, ** statistically highly significant

There was a significant reduction of FVC, FEV_1 and PEFR and a significant increase in FEV_1/FVC ratio among the exposed population as compared to unexposed population.

Table 3: Duration of exposure to dust in years of exposed population.

Duration of exposure to dust in years	**No. of exposed**	**%**
1-5	65	32.5
5-10	125	62.5
>10	10	5.0
Total	200	100.0

Distribution of exposed group in percentage according to duration of exposure to dust in years.

Graph 1: Duration of exposure in years

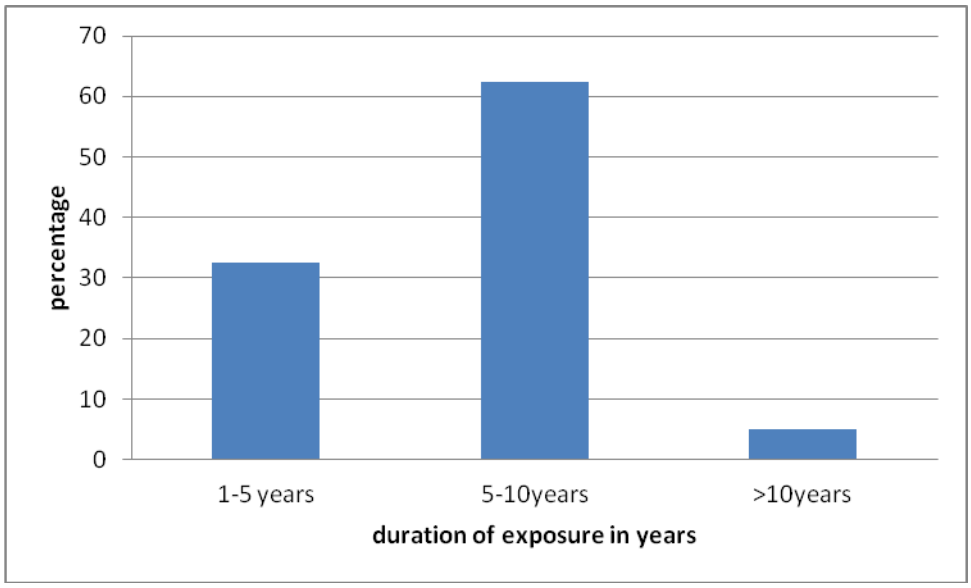


Table 4: Comparison of PFT with duration of exposure in years of three groups studied among the exposed population by ANOVA test.

PFT	Duration of exposure in years			P value
	1-5	5-10	>10	
FVC(L)	2.79±0.38	2.07±0.23	1.37±0.18	<0.001**
FEV_1(L)	2.28±0.60	1.89±0.42	1.27±0.15	<0.001**
PEFR(L/S)	5.76±2.80	4.64±1.80	2.94±0.91	<0.001**
FEV_1/FVC%	82.62±22.09	91.56±17.60	93.92±8.71	0.006*

* Statistically significant, ** statistically highly significant.

There was a significant decrease in FVC, FEV_1 and PEFR and a significant increase in FEV_1/FVC ratio with increasing duration of exposure in years.

Table 5: Post hoc test (Bonferroni test) to compare means of FVC, FEV_1, FEV_1/FVC and PEFR between the three study groups.

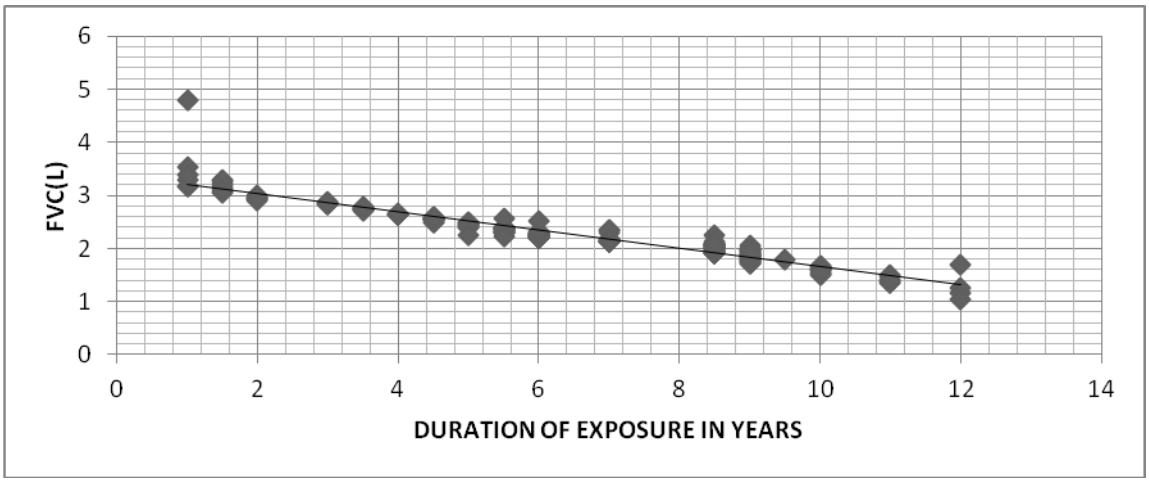
Study group	FVC(L)	FEV_1(L)	FEV_1/FVC(%)	PEFR(L)
1-5years vs 5-10 years of exposure to dust	p=0.000**	p=0.000**	p=0.007*	p=0.002*
5-10 years vs >10years of exposure to dust	p=0.000**	p=0.000**	p=1.0	p=0.051
1-5years vs >10years exposure to dust	p=0.000**	p=0.000**	p=0.24	p=0.000**

* Statistically significant, ** statistically highly significant.

It is seen that there was a significant decrease in FVC, FEV_1 and PEFR among the quarry workers who were exposed to dust for 5-10 years and >10years in comparison to those exposed for 1-5 years. There was also a significant decrease in FVC, FEV_1 among the quarry workers who were exposed to dust for >10 years in comparison with those

exposed for 5-10 years.

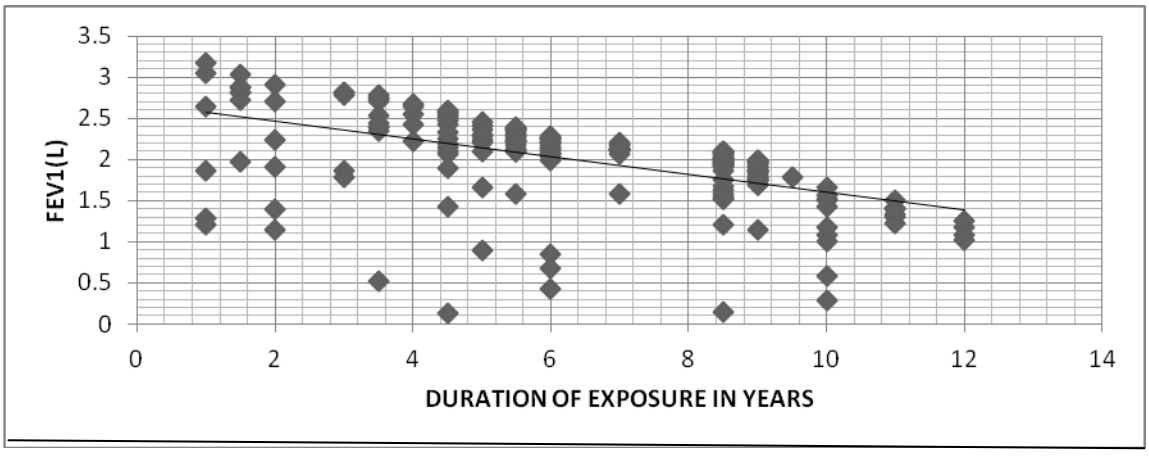
Graph 2: Correlation of Duration of Exposure in years with FVC of Exposed Population.



n=200, r= -0.86, p= 0.01

A significant negative correlation was seen between duration of exposure in years and FVC of exposed population.

Graph 3: Correlation of Duration of Exposure in years with FEV_1 of Exposed Population.

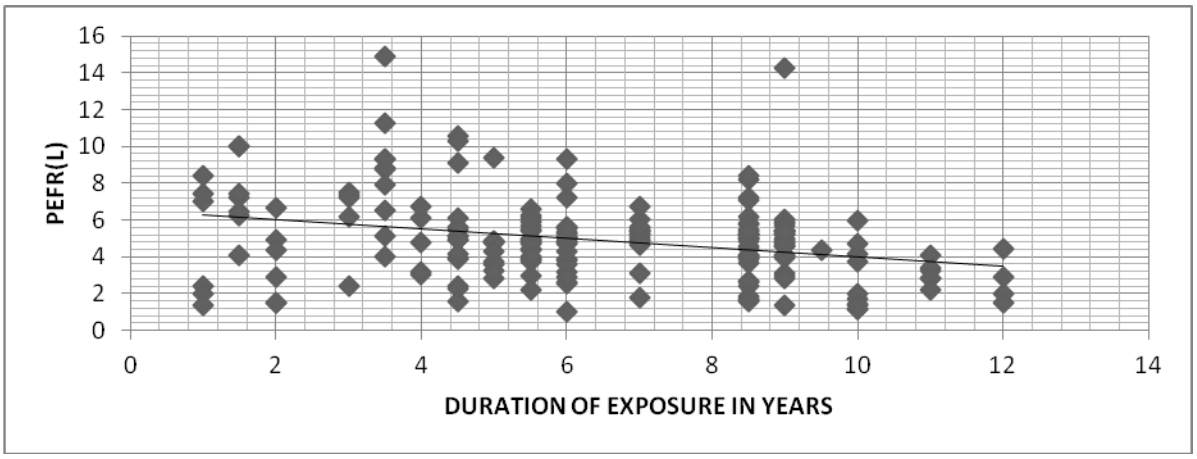


n=200 , r= -0.50, p=0.01

A significant negative correlation was seen between duration of exposure in years and

FEV_1 of exposed population.

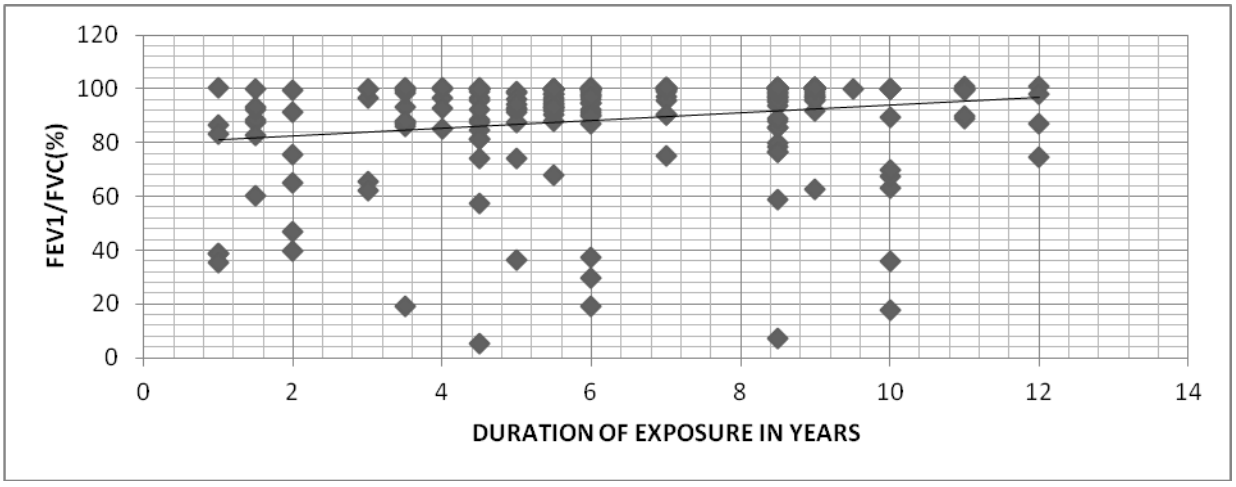
Graph 4: Correlation of Duration of Exposure in years with PEFR of Exposed Population.



n=200, r= -0.30, p=0.01

A significant negative correlation was seen between duration of exposure in years and PEFR of exposed population.

Graph 5: Correlation of Duration of Exposure in years with FEV1/FVC of Exposed Population.



n=200, r= 0.17, p=0.05

A significant positive correlation between duration of exposure in years and FEV_1/FVC ratio of exposed population.

Table 6: Occupational category among the exposed population

CATEGORIES	**No. of exposed population**	**%**
Blasters	44	22.0
Drillers	39	19.5
Loaders	39	19.5
Supervisors	13	6.5
Stone cutters	26	13.0
Stone grinders	39	19.5
Total	200	100.0

Shows distribution of various categories of exposed population in percentage.

Table 7: Comparison of the pulmonary function parameters among the various categories of exposed population by ANOVA test

Variables	**Category**						**P value**
	Blasters	**Drillers**	**Loaders**	**Supervisors**	**Stone cutters**	**Stone grinders**	
FVC(L)	2.45±0.1	2.23±0.08	1.65±0.22	3.27±0.5	2.84±0.19	2.01±0.07	<0.001**
FEV_1(L)	2.18±0.44	2.01±0.43	1.48±0.37	2.38±0.56	2.38±0.64	1.86±0.34	<0.001**
PEFR(L/S)	4.96±1.92	4.82±1.59	3.92±2.35	6.49±2.6	6.09±3.22	4.68±1.53	<0.001**
FEV_1/FVC %	89.21±17.88	90.74±19.28	90.17±18.71	74.55±19.8	84.44±23.23	92.54±16.81	0.060

** Statistically highly significant

FVC, FEV_1 and PEFR was statistically significant among the various categories of exposed population.

Table 8: Post hoc test (Bonferroni) to compare means of FVC, FEV_1, FEV_1/FVC and PEFR between the six categories of quarry workers.

Category of workers	FVC(L)	FEV_1(L)	FEV_1/FVC(%)	PEFR(L)
Blasters vs drillers	p=0.000**	p=1.000	p=1.00	p=1.00
Drillers vs loaders	p=0.000**	p=0.000**	p=1.00	p=0.966
Loaders vs supervisors	p=0.000**	p=0.000**	p=0.166	p=0.004*
Supervisors vs stone cutters	p=0.000**	p=1.000	p=1.00	p=0.150
Stone cutters vs stone grinders	p=0.000**	p=0.000**	p=1.00	p=0.426
Blasters vs loaders	p=0.000**	p=0.000**	p=1.00	p=0.001*
Loaders vs stone cutters	p=0.000**	p=0.000**	p=1.00	p=0.243
Drillers vs supervisors	p=0.000**	p=0.160	p=0.127	p=0.138
Supervisors vs stone grinders	p=0.000**	p=0.005*	p=0.053	p=1.00
Blasters vs stone grinders	p=0.000**	p=0.022*	p=1.00	p=1.00
Loaders vs stone grinders	p=0.000**	p=0.004*	p=1.00	p=1.00

* Statistically significant, ** statistically highly significant.

Loaders had significant decrease in FVC and FEV_1 in comparison with the other five categories. FVC of drillers was significantly lower in comparison with blasters and supervisors. It was also found that FVC, FEV_1 was significantly lower among the stone grinders in comparison with stone cutters, supervisors and blasters.

Table 9: Smoking in pack years among the exposed population

Smoking	**No. of exposed**	**%**
Nil	15	7.5
1-5	156	78.0
>5	29	14.5
Total	200	100.0

Shows distribution of exposed group in percentage according to smoking in pack years.

Table 10: Simple linear regression for duration of exposure in years of various spirometric parameters.

	Regression coefficient	t value	Pvalue
FVC	-0.948	-42.074	p=0.000**
FEV_1	-0.543	-9.089	p=0.000**
FEV_1/FVC	0.202	2.905	p=0.004*
PEFR	-0.307	-4.53	p=0.000**

* Statistically significant, ** statistically highly significant.

Table 11: Multiple regression of FVC with its predictors

Predictor variable	**FVC(L) (Dependent variable)**			
	Simple linear regression coefficient	Multiple linear regression coefficient	t value	p value
Duration of exposure in years	-0.948	-0.948	-42.074	0.000*
Smoking in pack years	-	0.044	1.965	0.051
Height	-	0.033	1.49	0.138

* statistically highly significant.

Duration of exposure is an independent risk factor of decrease in FVC.

Table 12: Multiple regression of FEV_1 with its predictors

Predictor variable	**FEV_1(L) (Dependent variable)**			
	Simple linear regression coefficient	Multiple linear regression coefficient	t value	p value
Duration of exposure in years	-0.642	-0.642	-18.907	0.000*
Smoking in pack years	-	-0.702	-20.96	0.000*
Height	-	-0.004	-0.063	0.949

* statistically highly significant.

Smoking is a confounder and it is a risk factor of FEV_1. Duration of exposure in years is also a risk factor for decrease in FEV_1.

Table 13: Multiple regression of FEV_1/FVC with its predictors

Predictor variable	**FEV_1/ FVC(%) (Dependent variable)**			
	Simple linear regression coefficient	Multiple linear regression coefficient	t value	p value
Duration of exposure in years	0.202	0.085	2.225	0.027
Smoking in pack years	-	-0.833	-21.881	0.000*
Height	-	-0.033	-0.861	0.39

* statistically highly significant.

Smoking is a confounder of FEV_1/FVC ratio. Smoking decreases FEV_1/FVC ratio which is statistically significantly.

Whereas, FEV_1/ FVC ratio remains normal or increased as the duration of exposure in years increases which is also statistically significant.

Table 14: Multiple regression of PEFR with its predictors.

Predictor variable	**PEFR(L) (Dependent variable)**			
	Simple linear regression coefficient	Multiple linear regression coefficient	t value	p value
Duration of exposure in years	-0.307	-0.336	-5.016	0.000
Smoking in pack years	-	-0.205	-3.07	0.002
Height	-	0.042	0.639	0.524

Duration of exposure is an independent risk factor of decrease in PEFR

DISCUSSION

DISCUSSION

Silicosis is one of the oldest occupational disease known to man and it was first reported in India from Kolar Gold Fields by Dr.Krishnswami as early as in 1935.This paved the way for ground breaking research and establishment of company rules for protection of workers. But silicosis continues to affect people all over the world in developed and developing countries. The latest estimate is that 3 million people in our country are exposed to silica that is without including many more in industries like construction.[52] An important group of workers exposed to this highly toxic dust belong to those in quarry industry and they belong to the unorganized sector. Inhalation of silica leads to adverse respiratory effects like chronic bronchitis which further leads to the development of silicosis. Silicosis is a predisposing factor for the development of pulmonary tuberculosis and lung cancer.[37, 39] It must be stressed that silicosis cannot be treated and hence the primary need is prevention or at least early detection. This study was designed to find the respiratory health status of the quarry workers, increase their awareness regarding the disease and educate them in preventive measures.

Spirometric results of the quarry workers in our study showed pulmonary dysfunction with forced vital capacity(FVC), forced expiratory volume at the end of 1st second (FEV_1), peak expiratory a flow rate (PEFR) and FEV_1/FVC values being statistically lower than the unexposed group. The pathophysiology of impairment of lung functions among quarry workers is most likely due to the deposition of quarry dust consisting of silica in the lungs by inhalation. This causes irritation and inflammatory reactions by activating macrophages which ingest them, and releases the contents of

lysosomes with acidic pH and the digestive enzymes which degrades and clears the particles. They also release chemicals to activate other macrophages. Alveolar macrophages have an average life span of about 50 days. When they die, they release their contents which consist of already engulfed particles which further lead to recruitment of new macrophages. This cycle of cell death and newly recruited cells in the alveoli can lead to increased inflammation, lower rate of particle clearance and a reduced capacity of the lung to exchange gas. Healing of this inflammatory process would cause fibrosis leading to defective oxygen diffusion and impaired pulmonary function.[29] This leads to pulmonary dysfunction of the restrictive type. The FEV_1 and FVC are significantly reduced in quarry workers as quoted earlier but the FEV_1/FVC was above 70% showing a restrictive abnormality which is also recorded by many others. [33,53]

The decrease in PEFR is significant among quarry workers which may be again due to increased dust exposure. Peak flow is largely a function of the large caliber airways. It greatly depends on expiratory muscle strength. A study done on sand stone quarry workers reveals that the duration of exposure affects the peak expiratory flow rate of lungs. [51]

Among the quarry workers we studied, 62.5% were exposed to dust for 5-10 years, 32.5% of them were exposed to dust for 1-5 years and only 5% of them were exposed to dust for more than 10 years. It was seen that increase in duration of exposure to dust in years decreased PFT and there was a significant negative co relation between duration of exposure to dust and pulmonary function. In our study pulmonary function impairment was seen within 5 years of exposure. Post hoc Bonferroni test revealed that the lung impairment was significantly higher among the quarry workers exposed to dust

for >10 years and 5-10 years in comparison with 1-5 years. Our study corroborated with many studies where the pulmonary function tests declined with increasing duration of exposure to dust. A study in Nigeria showed a significant decrease in FVC and FEV_1 among the quarry workers of stone crushing industry exposed to dust.[38] Another study done on stone crushers found that PFT bears relationship with duration of exposure, as the duration of exposure increases the PFT goes on decreasing. [54] PFT on quarry workers in Nagpur showed impairment after 15years and they document that the cumulative dust exposure recorded among them was less.[55] A study on stone cutters of Iranian factory showed impairment of lung function with >20 years of exposure to dust.[56] PFT on the quarry workers in Chennai revealed impairment of lung functions among those exposed to dust for >15 years.[57] A study done by Chattopadhyay among stone crushing workers found that there was a significant decrease in FVC, FEV_1/FVC ratio with the increase in duration of exposure. [58] Another study by Johncy on construction workers found an increase in lung impairment with increase in duration of exposure to dust in years. [49]

The quarry workers were further categorized based on their work as blasters, drillers, loaders, stone cutters, stone grinders and supervisors depending on their job description, as the quantity of dust exposure varied with their job. Lung functions were significantly lower among all the categories except supervisors. This may be attributed to the fact that supervisors were exposed to less cumulative dust. Loaders were affected the most, which may be due to high cumulative dust exposure and also longer duration of exposure among them. Stone grinders were affected next with significantly lower FVC and FEV_1 in comparison with blasters, stone cutters and supervisors. FVC of drillers was significantly lower in comparison with blasters and supervisors. Among the various

categories, blasters and stone cutters were found to be affected the least. It was also observed that there was a decrease in FVC as well as FEV_1 with FEV_1/FVC ratio that was normal or increased among the different categories suggestive of restrictive type of lung disease. Most studies assessed quarry workers as whole and did not categorize them. A study in Iran showed that hammer drillers were more affected due to high concentration of dust exposure, whereas, subjects exposed to dry-cutting a relatively new, artificial, decorative stone product with high crystalline silica content, had moderate-to-severe restrictive lung disease. [59, 44] In another study in Iranian factory workers they showed that stone grinders were affected more as the cumulative dust exposure among them was higher in comparison with the stone cutters, which was consistent with our study.[56] The Nagpur study did not show any difference between stone cutters and grinders and that may be because of the very low cumulative dust exposure recorded.[55]

Smoking is a risk factor for the development of lung impairment. In our study, 92.5% of the quarry workers were smokers of which majority of them (78%) smoked 1-5 pack years and 14.5% of them smoked more than 5 pack years . 7.5% were found to be non smokers. In our study smoking was found to an important contributor to the decrease in FEV_1. Results of previous studies have also corroborated that there has been significant decline in lung function values among individuals with both silica and tobacco exposure than in those with either one, per se.[60,61] Though smoking can change the pattern from restrictive pulmonary disease to obstructive type, in our study they showed a restrictive type of pulmonary dysfunction.[62]

Regression analysis was done to know independent risk factor of restrictive type of lung disease seen among the exposed population. Simple linear regression for duration

of exposure in years of various spirometric parameters was done and then, multiple regression analysis was done to know if smoking was a confounding factor. Duration of exposure as well as smoking was found to be predisposing factors for decrease in FEV_1. After adjusting for smoking, duration of exposure in years was found to be an independent risk factor for decrease in FVC, PEFR and increase in FEV_1/FVC ratio suggesting that, the duration of exposure in years is an independent risk factor for restrictive type of lung disease among the quarry workers.

A modified prevalidated respiratory questionnaire was used to assess the chronic symptoms of pulmonary dysfunction if any, on the quarry workers and unexposed population. 95% of the quarry workers did not complain of any respiratory symptoms like chronic cough, phlegm production or breathlessness in contrast to the Nigerian study on quarry workers where they quoted occasional cough as high as 40.7% and blood stained sputum of 6.5%. [38] This contrast may be due to the fact that silicosis is known to present in three forms, acute form, accelerated form and chronic form. In the chronic form the patients are known to be symptomless for 10-20 years. [22, 56] As 95% of our exposed group had an exposure to dust of less than 10 years they may be oligosymtomatic .The other plausible explanation may be due to the fear of losing their livelihood or repercussions from the management as they belonged to the unorganized sector. Quarry workers in our study exposed to dust had significant reduction in pulmonary function parameters with a restrictive pattern but the questionnaire result mainly was in the negative showing that questionnaire was an inadequate screening tool.

The quarry workers reported that their work was performed without dust suppression (e.g., wet as opposed to dry cutting or effective local ventilation), typically

working without any personal respiratory protection for an average of 10 hours daily. The results of our study were shared and discussed with the quarry workers with regard to their pulmonary function, duration of exposure to dust and smoking habit. An attempt was made to educate the workers to healthy lifestyle, necessity to stop smoking, usage of protective gear and regular medical examination. They were also provided with masks as one of the steps of occupational health measures.

Management and supervisors were educated on the importance of prevention of health hazards at source by using engineering measures such as enclosure and effective ventilation, pre-employment screening, use of suitable personal protective equipment (PPE), education, training and supervision of workers, environmental monitoring and health surveillance.

CONCLUSION AND SUMMARY

CONCLUSIONS

- PFT of quarry workers was significantly reduced as compared to that of unexposed group.
- Duration of exposure to dust was an independent risk factor for the decrease in PFT.
- Lung impairment was more among the loaders followed by stone grinders, drillers, blasters and stone cutters showing that cumulative dust exposure was a contributing factor.
- Smoking was a contributing factor.
- Respiratory questionnaire was ineffective as a screening tool to assess the lung impairment in quarry workers.
- PFT analysis served as a useful tool in early diagnosis of lung impairment among the quarry workers.

SUMMARY

This study was conducted to evaluate the effect of dust and duration of exposure to dust in stone quarry workers. 200 quarry workers and 200 unexposed subjects were subjected to pulmonary function tests. Statistical analysis revealed that quarry workers had significantly reduced PFT values as compared to unexposed group and they had a restrictive pattern of lung disease. There was a significant negative correlation between pulmonary function and duration of exposure among the quarry workers and duration of exposure was an independent risk factor in the decreasing pulmonary function . Among the quarry workers, the loaders were the most affected followed by stone grinders, drillers, blasters and stone cutters showing that more the cumulative exposure to dust , worse were their pulmonary functions. 95% of the quarry workers smoked and smoking contributed significantly to decrease in FEV_1. A modified prevalidated respiratory questionnaire was used to assess the chronic symptoms of pulmonary dysfunction if any, on the quarry workers and unexposed population. Though quarry workers showed significant decrease in pulmonary function, only 4.5% of the quarry workers complained of cough, sputum production and breathlessness. Hence, questionnaire cannot be used as an effective screening tool to assess the lung impairment and PFT analysis might be necessary for early diagnosis of lung impairment among the quarry workers. Therefore, the prevention of occupational diseases calls for a multi-disciplinary approach such as, enclosure and effective ventilation, other complementary control measures including administrative control, pre-employment screening, use of suitable personal protective equipment (PPE), education, training and supervision of workers, environmental monitoring and health surveillance.

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ANNEXURES

A. PROFORMA FOR QUESTIONNAIRE

1. Years of occupation _____ years/months
2. Hours of work per day _____
3. What was your previous job?_____
4. Do you usually cough first thing in the morning or on getting up? ____
5. Do you cough like this on most of the days for as much as three months each year? _____
6. Do you cough at work? _____
7. Do you usually bring up some phlegm from your chest first thing in the morning or on getting up?(count phlegm with first smoke, on first going out of doors. Count swallowed phlegm. Exclude phlegm from the nose) _____
8. Do you bring up phlegm like this on most of the days for as much as three months each year?_____
9. In the past three years , have you had a period of (increased) cough and phlegm lasting 3 weeks or more? _____
10. Have you had more than one such period? _____
11. Does your chest feel tight or your breathing becomes difficult?____
12. During past three years have you had any chest illness which has kept you off work or from usual activities for as much as a week?_____
13. Have you ever smoked?_____
14. How long have you been smoking?_____
15. How many per day? _____
16. Smoking in pack years _____

B. MASTER CHART OF QUESTIONNAIRE

SL NO	Hours of work per day	Do you usually cough first thing in morning when you get up?	Do you cough like this on most of the days as much as 3 months each year?	Do you usually bring up phlegm first thing in morning when you get up?	Do you usually bring up phlegm like this on most of the days for as much as 3 months each year?	In the past 3 years have you had a period of cough and phlegm lasting 3 weeks or more?	Does your chest feel tight or breathing becomes difficult?
1	8	no	no	no	no	no	no
2	10	no	no	no	no	no	no
3	8	no	no	no	no	no	no
4	7	no	no	no	no	no	no
5	10	no	no	no	no	no	no
6	11	yes	yes	yes	yes	yes	yes
7	10	no	no	no	no	no	no
8	11	yes	yes	yes	yes	yes	yes
9	10	no	no	no	no	no	no
10	10	no	no	no	no	no	no
11	5	no	no	no	no	no	no
12	7	no	no	no	no	no	no
13	9	no	no	no	no	no	no
14	10	no	no	no	no	no	no
15	10	no	no	no	no	no	no
16	11	no	no	no	no	no	no
17	10	yes	yes	yes	yes	yes	yes
18	10	no	no	no	no	no	no
19	13	no	no	no	no	no	no
20	10	no	no	no	no	no	no
21	12	no	no	no	no	no	no
22	8	no	no	no	no	no	no
23	8	no	no	no	no	no	no
24	9	no	no	no	no	no	no
25	12	no	no	no	no	no	no
26	10	no	no	no	no	no	no
27	10	no	no	no	no	no	no
28	11	no	no	no	no	no	no
29	12	no	no	no	no	no	no

SL NO	Hours of work per day	Do you usually cough first thing in morning when you get up?	Do you cough like this on most of the days as much as 3 months each year?	Do you usually bring up phlegm first thing in morning when you get up?	Do you usually bring up phlegm like this on most of the days for as much as 3 months each year?	In the past 3 years have you had a period of cough and phlegm lasting 3 weeks or more?	Does your chest feel tight or breathing becomes difficult?
30	12	no	no	no	no	no	no
31	11	no	no	no	no	no	no
32	10	no	no	no	no	no	no
33	10	no	no	no	no	no	no
34	11	no	no	no	no	no	no
35	9	no	no	no	no	no	no
36	13	no	no	no	no	no	no
37	10	no	no	no	no	no	no
38	12	no	no	no	no	no	no
39	11	no	no	no	no	no	no
40	11	no	no	no	no	no	no
41	11	no	no	no	no	no	no
42	10	no	no	no	no	no	no
43	9	no	no	no	no	no	no
44	9	no	no	no	no	no	no
45	8	no	no	no	no	no	no
46	9	no	no	no	no	no	no
47	10	no	no	no	no	no	no
48	9	no	no	no	no	no	no
49	11	no	no	no	no	no	no
50	12	no	no	no	no	no	no
51	12	no	no	no	no	no	no
52	12	no	no	no	no	no	no
53	12	no	no	no	no	no	no
54	8	no	no	no	no	no	no
55	8	no	no	no	no	no	no
56	8	no	no	no	no	no	no
57	9	no	no	no	no	no	no
58	10	no	no	no	no	no	no
59	11	no	no	no	no	no	no
60	8	no	no	no	no	no	no
61	10	no	no	no	no	no	no
62	8	no	no	no	no	no	no
63	7	no	no	no	no	no	no
64	10	no	no	no	no	no	no
65	11	no	no	no	no	no	no

SL NO	Hours of work per day	Do you usually cough first thing in morning when you get up?	Do you cough like this on most of the days as much as 3 months each year?	Do you usually bring up phlegm first thing in morning when you get up?	Do you usually bring up phlegm like this on most of the days for as much as 3 months each year?	In the past 3 years have you had a period of cough and phlegm lasting 3 weeks or more?	Does your chest feel tight or breathing becomes difficult?
66	10	no	no	no	no	no	no
67	11	no	no	no	no	no	no
68	10	no	no	no	no	no	no
69	10	no	no	no	no	no	no
70	5	no	no	no	no	no	no
71	7	no	no	no	no	no	no
72	9	no	no	no	no	no	no
73	10	no	no	no	no	no	no
74	10	no	no	no	no	no	no
75	11	no	no	no	no	no	no
76	10	no	no	no	no	no	no
77	10	no	no	no	no	no	no
78	13	no	no	no	no	no	no
79	10	no	no	no	no	no	no
80	12	no	no	no	no	no	no
81	8	no	no	no	no	no	no
82	8	no	no	no	no	no	no
83	9	no	no	no	no	no	no
84	12	no	no	no	no	no	no
85	10	no	no	no	no	no	no
86	10	no	no	no	no	no	no
87	11	no	no	no	no	no	no
88	12	no	no	no	no	no	no
89	12	no	no	no	no	no	no
90	11	no	no	no	no	no	no
91	10	no	no	no	no	no	no
92	10	no	no	no	no	no	no
93	11	no	no	no	no	no	no
94	9	no	no	no	no	no	no
95	13	no	no	no	no	no	no
96	10	no	no	no	no	no	no
97	12	no	no	no	no	no	no
98	11	no	no	no	no	no	no
99	11	no	no	no	no	no	no
100	11	no	no	no	no	no	no
101	10	yes	yes	yes	yes	yes	yes

SL NO	Hours of work per day	Do you usually cough first thing in morning when you get up?	Do you cough like this on most of the days as much as 3 months each year?	Do you usually bring up phlegm first thing in morning when you get up?	Do you usually bring up phlegm like this on most of the days for as much as 3 months each year?	In the past 3 years have you had a period of cough and phlegm lasting 3 weeks or more?	Does your chest feel tight or breathing becomes difficult?
102	9	no	no	no	no	no	no
103	9	no	no	no	no	no	no
104	8	no	no	no	no	no	no
105	9	no	no	no	no	no	no
106	10	no	no	no	no	no	no
107	9	no	no	no	no	no	no
108	11	no	no	no	no	no	no
109	12	no	no	no	no	no	no
110	12	no	no	no	no	no	no
111	12	no	no	no	no	no	no
112	12	no	no	no	no	no	no
113	8	no	no	no	no	no	no
114	8	no	no	no	no	no	no
115	8	no	no	no	no	no	no
116	9	no	no	no	no	no	no
117	10	no	no	no	no	no	no
118	11	no	no	no	no	no	no
119	8	no	no	no	no	no	no
120	10	no	no	no	no	no	no
121	8	no	no	no	no	no	no
122	7	no	no	no	no	no	no
123	10	no	no	no	no	no	no
124	11	no	no	no	no	no	no
125	10	no	no	no	no	no	no
126	11	no	no	no	no	no	no
127	10	no	no	no	no	no	no
128	10	no	no	no	no	no	no
129	5	no	no	no	no	no	no
130	7	no	no	no	no	no	no
131	9	no	no	no	no	no	no
132	10	no	no	no	no	no	no
133	10	no	no	no	no	no	no
134	11	no	no	no	no	no	no
135	10	no	no	no	no	no	no
136	10	no	no	no	no	no	no
137	13	no	no	no	no	no	no

SL NO	Hours of work per day	Do you usually cough first thing in morning when you get up?	Do you cough like this on most of the days as much as 3 months each year?	Do you usually bring up phlegm first thing in morning when you get up?	Do you usually bring up phlegm like this on most of the days for as much as 3 months each year?	In the past 3 years have you had a period of cough and phlegm lasting 3 weeks or more?	Does your chest feel tight or breathing becomes difficult?
138	10	yes	yes	yes	yes	yes	yes
139	12	no	no	no	no	no	no
140	8	no	no	no	no	no	no
141	8	no	no	no	no	no	no
142	9	no	no	no	no	no	no
143	12	no	no	no	no	no	no
144	10	yes	yes	yes	yes	yes	yes
145	10	yes	yes	yes	yes	yes	yes
146	11	yes	yes	yes	yes	yes	yes
147	12	no	no	no	no	no	no
148	12	no	no	no	no	no	no
149	11	no	no	no	no	no	no
150	10	no	no	no	no	no	no
151	10	yes	yes	yes	yes	yes	yes
152	11	no	no	no	no	no	no
153	9	no	no	no	no	no	no
154	13	no	no	no	no	no	no
155	10	no	no	no	no	no	no
156	12	no	no	no	no	no	no
157	11	no	no	no	no	no	no
158	11	no	no	no	no	no	no
159	11	no	no	no	no	no	no
160	10	no	no	no	no	no	no
161	9	no	no	no	no	no	no
162	9	no	no	no	no	no	no
163	9	no	no	no	no	no	no
164	9	no	no	no	no	no	no
165	10	no	no	no	no	no	no
166	9	no	no	no	no	no	no
167	10	no	no	no	no	no	no
168	12	no	no	no	no	no	no
169	12	no	no	no	no	no	no
170	12	no	no	no	no	no	no
171	11	no	no	no	no	no	no
172	8	no	no	no	no	no	no
173	8	no	no	no	no	no	no

SL NO	Hours of work per day	Do you usually cough first thing in morning when you get up?	Do you cough like this on most of the days as much as 3 months each year?	Do you usually bring up phlegm first thing in morning when you get up?	Do you usually bring up phlegm like this on most of the days for as much as 3 months each year?	In the past 3 years have you had a period of cough and phlegm lasting 3 weeks or more?	Does your chest feel tight or breathing becomes difficult?
174	8	no	no	no	no	no	no
175	9	no	no	no	no	no	no
176	10	no	no	no	no	no	no
177	12	no	no	no	no	no	no
178	8	no	no	no	no	no	no
179	10	no	no	no	no	no	no
180	8	no	no	no	no	no	no
181	7	no	no	no	no	no	no
182	10	no	no	no	no	no	no
183	11	no	no	no	no	no	no
184	10	no	no	no	no	no	no
185	11	no	no	no	no	no	no
186	10	no	no	no	no	no	no
187	10	no	no	no	no	no	no
188	5	no	no	no	no	no	no
189	7	no	no	no	no	no	no
190	9	no	no	no	no	no	no
191	10	no	no	no	no	no	no
192	10	no	no	no	no	no	no
193	11	no	no	no	no	no	no
194	11	no	no	no	no	no	no
195	11	no	no	no	no	no	no
196	10	no	no	no	no	no	no
197	9	no	no	no	no	no	no
198	11	no	no	no	no	no	no
199	9	no	no	no	no	no	no
200	8	no	no	no	no	no	no

C.MASTER CHART (QUARRY WORKERS)

SL NO	age	Ht	Wt	BMI	FVC (L)	% PRED	FEV_1 (L)	% PRED	PEFR (L/S)	% PRED	FEV_1/FVC (%)	% PRED	DOO (yrs)	Category	Smoking (Pack yrs)
1	32	178	51	16.10	2.24	56	1.66	50	3.23	33	74.1	88	5	D	9
2	23	160	55	21.48	2.64	83	2.64	94	4.81	55	100	114	4	SC	2
3	26	162	56	21.34	2.09	64	2.09	74	5.19	59	100.48	116	8.5	SG	1.5
4	30	154	52	21.93	2	71	2	84	4.86	60	100	116	8.5	SG	1.5
5	29	162	60	22.86	2.21	69	2.21	80	4.82	56	100.45	117	6	D	2
6	29	170	66	22.84	2.47	68	0.89	29	4.75	51	36.17	42	5	B	30
7	24	162	68	25.91	1.9	58	1.67	58	8.17	93	87.89	100	8.5	L	2
8	24	174	50	16.51	2.74	70	0.52	15	14.91	154	18.97	22	3.5	SC	36
9	23	169	56	19.61	2.86	79	1.87	59	7.35	79	65.38	75	3	S	15
10	28	145	58	27.59	2.78	117	2.44	117	8.74	117	87.76	99	3.5	SC	3
11	28	165	70	25.71	2.73	81	2.34	81	11.29	127	86.02	100	3.5	SC	2.5
12	34	172	78	26.37	1.72	47	1.69	55	14.26	156	98.25	117	9	L	2
13	32	170	64	22.15	1.47	41	1.3	43	4.1	45	89.04	106	11	L	4
14	32	169	69	24.16	1.25	35	1.08	36	4.45	49	87.09	103	12	L	3
15	29	170	68	23.53	2.04	56	1.98	64	7.1	77	97.05	114	8.5	SG	1
16	29	168	66	23.38	2.49	71	2.29	76	9.39	104	92.33	108	5	B	0
17	30	178	68	21.46	2.29	57	0.85	25	3.19	32	37.28	44	6	D	30
18	28	159	52	20.57	2.63	85	2.23	84	6.13	72	85.11	98	4	SC	3
19	35	163	45	16.94	2.23	70	2.13	80	7.22	85	95.94	114	6	D	2
20	35	152	62	26.84	2.13	81	2.06	93	6.06	78	97.16	115	7	D	3
21	24	152	55	23.81	1.73	64	1.69	84	5.9	65	96.99	115	9	L	3
22	23	170	61	21.11	3.53	95	3.05	95	8.42	89	86.64	100	1	S	2
23	35	156	56	23.01	3.22	114	2.82	119	7.22	90	87.57	104	1.5	S	0
24	26	174	52	17.18	3.18	82	2.81	85	10.03	105	88.36	103	1.5	S	2
25	26	163	45	16.94	3.29	100	2.72	95	6.27	71	82.92	95	1.5	S	3
26	30	160	52	20.31	2.13	69	2.13	81	3.14	37	100.47	117	7	D	2.5
27	26	150	55	24.44	2.21	83	2.2	94	5.03	64	100	113	6	D	4
28	27	160	60	23.44	2.23	71	2.18	80	5.03	59	98.19	113	6	D	1.5
29	29	152	56	24.24	2.13	78	2.11	90	5.21	66	99.52	114	7	D	2
30	36	156	52	21.37	2.36	84	2.24	95	4.35	54	94.91	113	5.5	B	3
31	35	160	60	23.44	2.26	74	2.04	80	2.58	31	90.26	107	6	D	2
32	32	169	58	20.31	2.25	64	2.22	75	3.82	42	99.1	117	6	D	1.25
33	34	170	60	20.76	2.32	85	2.1	71	3.89	43	90.51	108	5.5	B	3.75
34	36	172	83	28.06	2.56	71	2.26	75	5.11	56	88.28	106	4.5	B	2
35	31	168	72	25.51	2.09	60	2.04	69	4.12	46	98.07	115	8.5	SG	4
36	23	160	68	26.56	2.31	72	2.22	79	4.71	54	96.52	110	5.5	B	3.25
37	35	169	66	23.11	2.28	65	2.27	78	4.75	53	99.58	119	6	D	1.5
38	36	171	68	23.26	2.54	71	2.15	73	4.91	54	84.64	101	4.5	B	2
39	30	168	60	21.26	2.59	74	2.1	71	5.14	57	81.39	96	4.5	B	1.25

SL NO	age	Ht	Wt	BMI	FVC (L)	% PRED	FEV_1 (L)	% PRED	PEFR (L/S)	% PRED	FEV_1/FVC (%)	% PRED	DOO (yrs)	Category	Smoking (Pack yrs)
40	34	169	76	26.61	1.95	56	1.52	52	5.8	65	78.35	93	8.5	SG	9
41	25	169	74	25.91	2.23	61	2.22	71	5.93	64	100	116	5.5	D	3
42	29	168	82	29.05	2.12	60	2.12	71	6.71	74	100	117	7	D	2.5
43	23	164	56	20.82	2.39	70	2.37	80	5.66	63	99.57	114	5.5	B	2
44	26	156	68	27.94	1.86	63	1.86	72	3.1	37	100	114	9	L	3
45	23	168	72	25.51	2.36	65	2.31	74	2.99	32	97.88	113	5.5	B	2
46	29	170	82	28.37	2.56	71	2.53	82	3.87	42	98.82	116	4.5	B	3
47	34	160	86	33.59	2.64	87	2.55	100	3.05	36	96.59	114	4	SC	4
48	25	158	76	30.44	2.45	80	2.41	90	3.61	42	98.77	113	5	B	0
49	25	180	80	24.69	2.56	61	2.47	69	5.64	56	96.48	113	4.5	B	0
50	32	136	66	35.68	2.34	117	2.34	125	4.88	69	100	107	5.5	B	3
51	25	160	70	27.34	2.55	80	2.06	75	3.97	46	81.1	93	4.5	B	1.25
52	40	160	75	29.30	2.5	85	2.19	90	2.44	30	87.6	106	4.5	B	0
53	25	169	70	24.51	2.13	59	1.59	51	1.79	19	75	87	7	D	9
54	35	178	77	24.30	2.3	58	2.3	70	6.13	64	100	120	5.5	B	4
55	25	174	78	25.76	2.49	64	2.45	74	4.81	50	98.79	115	5	B	3
56	29	168	80	28.34	1.91	54	1.52	51	1.89	20	80	93	8.5	SG	4
57	29	172	58	19.61	2.96	98	2.24	107	2.9	38	75.67	109	2	S	9
58	32	169	72	25.21	2.07	59	2.07	70	4.98	55	100.48	119	8.5	SG	2.5
59	30	170	56	19.38	1.83	51	1.83	60	4.06	44	100.54	118	9	L	3.5
60	28	174	72	23.78	2.21	58	2.21	68	3.87	40	100.45	117	6	D	3
61	30	169	70	24.51	1.5	42	1.5	50	3.24	35	100	118	11	L	3.5
62	26	150	66	29.33	2.26	85	2.26	97	5.6	71	100	113	6	D	2
63	24	174	68	22.46	2.73	70	2.54	76	4	41	93.38	108	3.5	SC	3
64	26	168	70	24.80	2.43	68	2.21	72	3.72	40	91.32	106	5	B	4
65	40	169	75	26.26	2.75	80	2.39	85	9.29	106	87.22	106	3.5	SC	4.25
66	33	160	64	25.00	3.3	108	1.28	50	2.38	28	38.78	45	1	S	30
67	30	169	82	28.71	2.29	74	2.29	76	8	95	100	103	6	D	2
68	35	172	74	25.01	1.75	48	1.75	58	3.97	43	100.57	120	9	L	3
69	29	172	78	26.37	1.66	44	1.66	52	3.71	39	100	117	10	L	4
70	28	163	78	29.36	1.93	59	1.93	68	3.95	45	100.52	117	8.5	SG	2
71	30	169	72	25.21	2.04	57	1.94	65	4.55	50	95.09	112	8.5	SG	2.5
72	29	172	80	27.04	2.24	60	2.12	67	3.62	38	94.64	111	6	D	3
73	36	172	74	25.01	2.34	65	1.59	53	2.23	24	67.94	81	5.5	B	12
74	28	165	65	23.88	1.6	47	1.01	35	1.16	13	63.12	73	10	L	12
75	34	176	80	25.83	2.28	59	1.99	62	2.65	28	87.28	104	6	D	0
76	34	174	66	21.80	1.88	50	1.86	60	3	41	100	119	9	L	1.5
77	32	166	58	21.05	1.17	34	1.17	41	2.92	33	100.86	119	12	L	2
78	35	154	68	28.67	1.41	51	1.41	61	3.38	43	100.71	119	11	L	4
79	36	162	80	30.48	1.52	49	1.52	58	4.17	50	100	119	10	L	2.25

SL NO	age	Ht	Wt	BMI	FVC (L)	% PRED	FEV_1 (L)	% PRED	PEFR (L/S)	% PRED	FEV_1/FVC (%)	% PRED	DOO (yrs)	Category	Smoking (Pack yrs)
80	32	169	72	25.21	1.76	50	1.76	59	4.56	50	100	118	9	L	3
81	25	156	45	18.49	2.4	81	2.1	81	4.83	58	87.5	100	5	B	2
82	18	171	63	21.55	2.39	62	2.09	62	3.91	40	87.81	100	5.5	B	2.5
83	20	170	84	29.07	2.25	60	2.07	63	4.3	45	92.41	106	6	D	3.5
84	31	160	69	26.95	2.4	55	2.24	64	4.85	57	93.03	109	5	B	3
85	39	180	65	20.06	2.2	55	2.08	64	4.71	49	94.54	115	6	D	2
86	21	172	78	26.37	2.3	60	2.13	64	4.46	46	92.6	106	5.5	B	4
87	35	176	79	25.50	2.39	62	2.22	70	5	53	93.27	112	5.5	B	3
88	24	172	75	25.35	2.27	60	2.26	69	5.31	56	100	116	6	D	2.25
89	35	178	75	23.67	2.3	58	2.17	66	4.91	51	94.34	113	5.5	B	4
90	31	152	71	30.73	2.04	76	1.98	86	3.87	49	97.05	112	8.5	SG	0.25
91	31	168	69	24.45	2.08	60	2.08	71	5.03	56	100	118	8.5	SG	0
92	21	180	75	23.15	2.02	48	1.95	53	5.21	51	96.53	112	8.5	SG	3
93	28	163	66	24.84	2.13	65	2.12	75	4.94	56	100	116	7	D	4.5
94	28	154	64	26.99	1.88	67	1.88	77	5.4	66	100	114	9	L	3.75
95	32	156	64	26.30	2.15	75	2.12	87	5.04	62	99.06	116	7	D	2
96	29	168	67	23.74	2.26	64	2.07	69	5.24	58	91.59	107	6	D	3
97	26	152	52	22.51	1.93	70	1.93	80	4.47	56	100.52	114	8.5	SG	3
98	21	164	71	26.40	1.84	54	1.84	61	4.78	52	100	114	9	L	2
99	19	170	68	23.53	2.21	59	2.15	65	5.06	53	97.72	111	6	D	3
100	26	154	59	24.88	2.31	81	2.11	85	3.77	46	91.73	105	5.5	B	4
101	35	168	54	19.13	2.21	64	0.42	14	2.9	32	19.09	22	6	D	36
102	28	168	80	28.34	2.95	84	1.91	63	6.69	74	64.96	75	2	S	12
103	39	162	68	25.91	2.55	83	2.43	96	6.11	74	95.66	115	4.5	B	4
104	34	169	82	28.71	2.38	68	2.38	82	6.63	74	100	119	5.5	B	3
105	25	169	72	25.21	3.26	90	1.97	63	10.03	108	60.42	70	1.5	S	10.5
106	32	168	58	20.55	1.99	57	1.99	68	5.4	60	100.5	119	9	SG	3
107	26	168	58	20.55	1.87	52	1.87	61	4.6	50	100.53	117	9	L	1.75
108	29	169	57	19.96	1.35	38	1.34	44	2.83	31	100	117	11	L	3
109	32	169	78	27.31	2.58	73	2.58	87	9.13	101	100	118	4.5	B	2
110	26	168	54	19.13	3.04	85	3.04	100	6.47	70	100	116	1.5	S	3
111	30	169	54	18.91	2.57	72	1.9	63	2.27	25	74.21	87	4.5	B	9
112	26	169	72	25.21	2.82	78	2.82	91	7.22	78	100	116	3	SC	2
113	33	169	58	20.31	2.2	63	2.2	75	9.34	104	100	118	6	D	2
114	40	162	60	22.86	1.82	66	1.75	84	5.8	77	96.15	127	9	L	3
115	35	160	56	21.88	2.59	85	2.59	102	4.92	59	100.38	119	4.5	B	3
116	39	163	56	21.08	1.63	52	1.09	42	1.73	20	67.28	81	10	L	12
117	26	168	72	25.51	2.89	81	2.78	91	7.52	82	96.52	112	3	S	2
118	25	170	78	26.99	3.13	85	2.88	91	4.06	43	92.3	107	1.5	SC	3
119	40	169	56	19.61	2.02	59	2	71	3.67	42	99	121	8.5	SG	3.25
120	25	169	72	25.21	2.57	71	0.13	4	10.55	114	5.07	5	4.5	B	30

SL NO	age	Ht	Wt	BMI	FVC (L)	% PRED	FEV_1 (L)	% PRED	PEFR (L/S)	% PRED	FEV_1/FVC (%)	% PRED	DOO (yrs)	Category	Smoking (Pack yrs)
121	34	168	56	19.84	2.53	73	2.33	81	4.17	47	92.46	110	4.5	B	1
122	27	172	66	22.31	2.63	70	2.43	76	3.19	34	92.74	108	4	SC	3
123	35	168	46	16.30	3.08	90	2.87	101	7.45	84	93.18	111	1.5	SC	3
124	38	168	74	26.22	1.6	47	1.43	51	1.97	22	89.37	107	10	L	0
125	28	168	80	28.34	1.91	54	1.63	54	2.39	26	85.78	100	8.5	SG	3
126	26	168	64	22.68	1.36	38	1.22	40	2.81	30	89.7	104	11	L	3
127	33	172	72	24.34	2.92	80	2.91	95	4.92	53	99.65	118	2	SC	3.5
128	22	167	54	19.36	2.82	79	2.82	91	6.15	66	100	114	3	SC	2.5
129	21	165	48	17.63	2.38	68	2.38	78	6.27	69	100	114	5.5	B	2.5
130	28	169	60	21.01	3.17	89	3.17	104	7.45	81	100.31	117	1	SC	3
131	26	165	59	21.67	1.04	30	1.02	34	2.02	22	98.07	113	12	L	2
132	34	168	78	27.64	2.36	69	2.36	82	4.78	54	100	119	5.5	B	2
133	39	168	46	16.30	2.47	73	2.36	85	4.33	50	95.93	116	5	B	2.75
134	28	172	69	23.32	2.53	68	2.52	79	5.49	58	100	117	4.5	B	3.25
135	23	168	56	19.84	3.39	94	1.2	38	1.35	14	35.5	41	1	SC	3.25
136	20	169	54	18.91	2.5	67	1.43	44	1.61	17	57.2	65	4.5	B	18
137	25	156	46	18.90	2.99	101	1.4	54	1.54	18	46.97	53	2	SC	20
138	30	162	54	20.58	2.91	91	1.15	42	1.54	17	39.65	46	2	SC	30
139	32	168	64	22.68	2.96	85	2.7	93	4.37	49	91.21	108	2	SC	3
140	25	172	62	20.96	2.86	76	1.78	55	2.41	25	62.23	72	3	SC	2
141	26	167	59	21.16	2.44	70	2.3	76	2.8	30	94.26	109	5	B	2
142	21	169	75	26.26	1.99	54	1.99	62	6.15	65	100.5	115	8.5	SG	2.5
143	21	169	75	26.26	2.33	63	2.27	71	4.02	42	97.84	112	5.5	B	0.5
144	25	169	72	25.21	2.25	62	0.67	21	1.04	11	29.91	34	6	D	32
145	28	169	49	17.16	1.65	46	0.59	19	1.43	15	35.97	42	10	L	30
146	26	168	78	27.64	1.6	45	0.28	9	1.15	12	17.5	20	10	L	36
147	24	164	58	21.56	1.68	50	1.17	40	1.4	15	69.64	80	10	L	9.75
148	26	168	68	24.09	1.82	51	1.14	37	1.37	15	62.63	72	9	L	10.5
149	26	168	82	29.05	1.99	56	1.86	61	2.62	28	93.93	109	8.5	SG	2
150	28	168	72	25.51	2.05	58	1.95	65	2.71	29	95.58	111	8.5	SG	3
151	26	172	85	28.73	4.8	128	1.87	58	2.02	21	38.95	45	1	S	32
152	26	169	72	25.21	1.77	49	1.77	57	4.09	44	100.56	116	9	L	0
153	23	160	59	23.05	1.95	61	1.95	70	4.07	46	100.51	114	8.5	SG	2
154	26	168	72	25.51	1.41	39	1.39	45	2.17	23	99.28	115	11	L	1.5
155	29	169	66	23.11	1.77	50	1.74	57	2.83	31	98.86	115	9	L	1.5
156	40	168	70	24.80	2.05	61	1.75	63	7.19	83	85.78	104	8.5	SG	3
157	39	165	46	16.90	3.18	99	2.64	100	7.03	83	83.01	100	1	S	3.5
158	35	168	56	19.84	2.03	59	1.55	54	1.73	19	76.73	92	8.5	SG	16.5
159	34	168	52	18.42	2.06	60	1.21	42	1.57	17	58.73	70	8.5	SG	16.5
160	32	168	54	19.13	1.91	55	0.14	4	1.68	18	7.36	8	8.5	SG	0
161	29	176	57	18.40	2.78	71	2.78	84	5.16	53	100	118	3.5	SC	0

SL NO	age	Ht	Wt	BMI	FVC (L)	% PRED	FEV_1 (L)	% PRED	PEFR (L/S)	% PRED	FEV_1/FVC (%)	% PRED	DOO (yrs)	Category	Smoking (Pack yrs)
162	25	172	62	20.96	2.75	73	2.7	83	6.55	69	98.54	115	3.5	SC	3
163	18	169	70	24.51	2.74	74	2.73	84	8.83	93	99.63	113	3.5	SC	3.5
164	20	181	68	20.76	2.72	63	2.39	64	7.93	77	87.86	108	3.5	SC	2.75
165	20	157	47	19.07	2.75	89	2.75	101	9.34	109	100.36	113	3.5	SC	2
166	18	162	43	16.38	1.91	57	1.91	64	5.76	64	100.52	113	8.5	SG	3
167	40	161	66	25.46	2.07	69	1.58	64	5.45	66	76.69	93	8.5	SG	9
168	24	164	52	19.33	2.67	79	2.67	91	6.74	75	100.37	115	4	SC	2
169	20	168	63	22.32	2.56	70	2.56	81	10.29	110	100	114	4.5	B	3
170	29	172	71	24.00	2.39	64	2.28	72	5.4	58	95.79	112	5.5	B	2
171	32	174	72	23.78	2.26	59	2.01	62	8.38	88	88.93	104	8.5	SG	3
172	28	179	68	21.22	2.34	57	2.12	61	5.24	53	90.59	106	7	D	2
173	30	178	70	22.09	2	49	1.94	57	4.92	50	97	115	9	SG	4
174	28	174	69	22.79	2.06	54	1.97	60	6.02	63	95.63	112	9	SG	2
175	29	169	49	17.16	2.3	64	2.2	72	5.43	59	95.65	112	7	D	2
176	24	174	71	23.45	2.02	52	2.02	60	5.19	53	100	116	8.5	SG	4
177	35	175	71	23.18	2.34	62	2.12	67	5.43	58	90.59	108	7	D	3
178	25	176	70	22.60	1.94	48	1.78	52	5.29	54	91.75	107	9	L	3.5
179	29	172	68	22.99	2.13	52	2.09	66	4.97	53	98.58	116	8.5	SG	2
180	30	173	73	24.39	2.56	68	2.39	76	5.47	58	93.35	110	5.5	B	4
181	32	175	72	23.51	2.32	61	2.25	70	5.64	60	96.98	115	6	D	3
182	31	154	71	29.94	2.51	66	2.25	71	5.56	59	90	106	6	D	2.75
183	23	168	67	23.74	1.51	42	1.51	48	5.97	64	100	116	10	L	4
184	26	169	59	20.66	1.91	53	1.91	62	5.24	57	100.52	116	9	SG	2
185	23	175	59	19.27	1.69	43	1.25	36	1.5	15	74.4	86	12	L	2
186	31	169	54	18.91	1.86	52	1.86	62	4.98	55	100	118	9	L	2.5
187	28	164	51	18.96	2.06	62	2.06	72	5.24	59	100	116	8.5	SG	0
188	29	178	58	18.31	2.13	53	2.13	63	4.63	47	100.47	118	7	D	0
189	27	170	60	20.76	1.56	43	1.56	50	4.68	50	100	116	10	L	1.5
190	38	168	65	23.03	2.18	64	2.18	78	5.47	62	100	120	7	D	2.5
191	28	170	69	23.88	1.8	50	1.8	58	5.4	58	100	116	9	L	2
192	35	172	63	21.30	1.96	54	1.96	65	4.61	50	100	120	9	SG	0
193	35	170	63	21.80	1.99	56	1.99	68	5.7	63	100.5	120	9	SG	3
194	29	167	64	22.95	2.17	63	2.17	73	4.82	53	100.46	117	7	D	0
195	21	163	58	21.83	1.95	58	1.95	66	5.19	58	100.51	114	9	SG	1.5
196	29	164	71	26.40	2.13	64	2.13	75	5.64	64	100.47	117	7	D	2
197	34	171	64	21.89	1.99	55	1.99	66	4.79	52	100.5	120	9	SG	3
198	23	168	58	20.55	1.91	53	1.91	61	5.4	58	100.52	116	9	SG	3
199	27	169	56	19.61	1.78	49	1.78	58	4.39	47	100	117	9.5	L	2.75
200	36	172	64	21.63	2.09	58	2.09	60	5.43	59	100.48	121	8.5	SG	2

D.MASTER CHART (UNEXPOSED GROUP)

SL NO	age	Ht	Wt	BMI	FVC (L)	% PRED	FEV_1 (L)	% PRED	PEFR (L/S)	% PRED	FEV_1/FVC (%)	% PRED
1	27	172	83	28.06	4	107	3.11	97	9.03	96	77.75	90
2	40	179	85	26.53	4.76	116	4.06	116	5.62	56	85.29	100
3	35	174	70	23.12	3.16	80	3.1	90	7.06	71	98.1	112
4	39	175	72	23.51	3.21	80	3.21	92	8.93	90	100.31	114
5	26	187	97	27.74	3.63	78	3.63	84	7.89	73	92.81	107
6	25	170	59	20.42	3.11	86	3.08	92	5.4	58	91.93	107
7	40	170	58	20.07	3.19	85	3.24	89	4.98	52	90.88	104
8	25	183	81	24.19	5.04	115	4.78	127	10.76	103	94.84	110
9	34	170	52	17.99	3.22	86	3.27	90	4.91	51	91.61	104
10	27	182	82	24.76	4.98	118	4.84	136	11.13	111	97.18	115
11	26	169	72	25.21	3.27	88	3.27	100	9.73	102	100.3	114
12	26	173	76	25.39	3.31	85	3.3	97	7.13	73	100	114
13	28	170	78	26.99	3.35	89	3.29	89	7.85	82	77.54	88
14	26	175	68	22.20	4.01	104	3.71	113	10.16	106	92.75	109
15	26	182	85	25.66	4.35	115	3.77	127	13.55	103	87.56	100
16	23	180	62	19.14	4.23	99	3.95	107	9.91	96	93.6	107
17	26	172	76	25.69	3.4	88	3.4	101	7.85	106	100	114
18	29	169	55	19.26	3.02	81	2.84	87	6.77	71	94.03	107
19	40	158	64	25.64	3.06	98	2.85	103	8	92	93.13	105
20	23	172	68	22.99	3.47	87	3.47	101	10.98	112	100.28	116
21	20	180	68	20.99	3.47	81	3.29	89	8.6	84	95.08	109
22	25	182	86	25.96	3.54	81	2.86	76	6.27	60	80.79	93
23	30	182	85	25.66	3.78	87	3.18	85	8.13	78	84.12	97
24	25	176	76	24.54	3.27	80	2.99	85	9.62	96	91.71	105
25	28	175	75	24.49	3.3	82	3.1	89	10.42	105	93.93	107
26	26	174	65	21.47	3.21	81	3.83	84	9.56	97	75.93	86
27	34	168	83	29.41	3.34	94	7.29	73	7.29	73	98.81	113
28	32	185	85	24.84	3.42	76	3.42	88	7.77	73	100	115
29	29	180	68	20.99	3.04	71	3.04	83	9.79	95	100	115
30	25	176	68	21.95	3.45	86	3.43	99	10.42	105	99.7	115
31	18	180	68	20.99	3.04	72	3.04	83	9.45	92	100	115
32	20	172	88	29.75	3.05	79	3.02	89	6.74	69	99.34	113
33	20	175	67	21.88	3.13	78	3.08	89	9.13	92	98.71	114
34	18	172	67	22.65	3.18	83	3.06	92	9.5	98	96.22	110
35	40	173	52	17.37	3.46	90	3.26	98	8.17	84	94.21	108
36	24	175	53	17.31	3.23	81	3.23	93	8	81	100.31	116
37	32	171	55	18.81	3.24	85	3.06	93	9.56	100	94.44	108

SL NO	age	Ht	Wt	BMI	FVC (L)	% PRED	FEV_1 (L)	% PRED	PEFR (L/S)	% PRED	FEV_1/FVC (%)	% PRED
38	25	174	58	19.16	3.62	98	3.21	101	9.67	103	88.67	103
39	26	183	75	22.40	3.42	78	3.26	86	8.74	84	95.32	111
40	21	182	75	22.64	3.84	90	3.53	97	8.83	87	91.92	108
41	39	172	80	27.04	3.26	88	2.28	72	7.35	78	69.93	81
42	35	160	56	21.88	3	96	2.95	110	8.17	96	98.33	113
43	21	169	56	19.61	2.76	79	2.76	95	7.56	84	100	119
44	28	154	43	18.13	2.95	104	2.9	117	8	98	98.63	113
45	24	162	52	19.81	3.12	97	2.99	109	7.85	91	95.83	111
46	29	164	56	20.82	2.94	87	2.86	97	7.59	85	97.27	111
47	32	168	56	19.84	2.93	83	2.93	97	7.74	85	100.34	117
48	28	163	52	19.57	3	92	2.87	103	7.29	84	95.66	111
49	30	162	52	19.81	3.15	96	2.97	105	7.16	82	94.58	109
50	28	154	52	21.93	2.64	94	2.64	108	7.81	96	100	114
51	29	173	73	24.39	3.29	90	2.91	97	9.62	106	88.71	107
52	29	172	85	28.73	4.39	114	3.65	108	9.69	87	83.33	94
53	30	171	84	28.73	3.7	97	3.69	111	9.34	97	99.72	113
54	32	174	54	17.84	3.22	81	3.11	90	7.42	75	96.58	110
55	31	172	56	18.93	3.71	96	3.71	110	8.51	87	100.27	114
56	33	175	54	17.63	3.85	104	3.81	120	9.23	98	99.21	116
57	24	172	58	19.61	2.65	69	2.6	77	8.13	83	98.48	112
58	35	168	58	20.55	2.69	73	2.69	84	6.71	71	100.37	113
59	25	170	109	37.72	3.04	81	2.91	89	8.42	88	95.72	109
60	33	180	68	20.99	2.98	70	2.98	81	9.56	93	100	115
61	22	168	56	19.84	3.11	87	3.11	100	6.74	73	100.32	115
62	26	168	60	21.26	3.01	82	2.99	93	7.06	75	99.66	113
63	28	168	65	23.03	3.33	95	3.28	109	8.04	88	98.79	115
64	26	171	60	20.52	3.36	88	3.23	98	8.25	86	96.13	110
65	34	168	63	22.32	3.92	110	3.15	103	7.25	79	80.35	93
66	39	165	63	23.14	3.27	91	3.16	101	6.88	74	96.93	111
67	35	168	65	23.03	3.71	104	2.64	86	10.42	113	71.35	83
68	38	163	63	23.71	3.86	116	2.75	95	10.84	122	71.24	82
69	29	167	66	23.67	3.68	110	2.92	100	10.55	118	79.34	90
70	26	172	78	26.37	3.94	106	2.78	87	9.18	98	70.55	82
71	32	172	70	23.66	3.38	92	3	98	10.42	113	88.75	105
72	32	164	68	25.28	3.01	92	2.71	99	7.19	83	90.33	107
73	23	174	80	26.42	3.61	94	3.47	92	10.35	108	90.9	109
74	26	170	75	25.95	3.3	94	3	104	7.1	79	90.9	109
75	30	172	74	25.01	2.99	82	2.73	91	7.03	77	91.61	110
76	29	172	64	21.63	3.13	87	2.85	97	6.66	74	91.34	110
77	29	163	70	26.35	3.17	97	2.86	102	6.77	78	90.5	105

SL NO	age	Ht	Wt	BMI	FVC (L)	% PRED	FEV_1 (L)	% PRED	PEFR (L/S)	% PRED	FEV_1/FVC (%)	% PRED
78	24	159	68	26.90	3.2	105	2.94	114	6.3	75	91.87	107
79	24	169	51	17.86	2.86	83	2.6	90	5.36	60	90.9	108
80	23	169	60	21.01	3.52	95	3.28	102	7.35	78	93.18	107
81	28	169	60	21.01	3.09	83	3.09	100	6.97	74	100.32	115
82	28	179	68	21.22	3.26	88	3.24	101	7.77	82	99.38	114
83	34	159	56	22.15	2.58	86	2.24	89	5.21	63	86.82	103
84	28	168	62	21.97	3.12	86	2.89	90	8.42	90	92.62	106
85	32	178	62	19.57	3.23	89	3.23	102	8.6	92	100.31	114
86	29	168	60	21.26	2.62	74	2.24	75	5.33	59	85.49	100
87	26	170	62	21.45	3.48	93	3.45	106	9.34	98	99.13	113
88	21	163	78	29.36	2.98	88	2.87	96	6.69	74	96.3	109
89	19	167	74	26.53	2.8	80	2.57	86	7.16	79	91.78	107
90	26	172	60	20.28	3.26	112	2.93	121	8.07	118	89.87	107
91	35	172	74	25.01	2.99	82	2.73	91	9.09	105	91.61	110
92	24	170	67	23.18	4.02	108	4	123	9.91	104	99.5	114
93	23	180	78	24.07	3.3	94	3	104	7.1	79	90.9	109
94	35	165	63	23.14	2.65	81	2.43	89	7.56	87	92.04	109
95	26	172	67	22.65	4.18	109	4.17	125	9.23	95	99.76	114
96	26	172	68	22.99	3.49	91	3.49	105	9.62	100	100.28	115
97	32	158	60	24.03	2.2	74	2.05	82	5.34	65	93.18	109
98	25	170	62	21.45	3.3	94	3	104	7.1	79	90.9	109
99	18	180	80	24.69	3.39	79	3.11	84	8.83	86	92.01	105
100	20	175	90	29.39	3.6	90	3.6	104	11.06	112	100	115
101	31	168	67	23.74	3.04	89	2.77	98	8.76	98	91.11	109
102	39	165	68	24.98	2.86	88	2.6	96	8.04	93	90.9	108
103	21	170	63	21.80	3.35	103	3.05	109	7.66	88	91.31	106
104	35	155	92	38.29	3.03	109	2.79	120	9.56	121	92.38	109
105	24	166	70	25.40	3.16	95	2.84	102	9.39	107	89.87	106
106	35	169	60	21.01	3.17	93	2.88	102	9.34	106	91.13	109
107	31	159	59	23.34	3.17	104	2.89	112	8.74	104	91.45	107
108	35	160	50	19.53	2.47	76	2.44	85	6.35	72	99.18	112
109	36	179	89	27.78	4.13	104	3.27	100	9.55	92	98.78	108
110	30	183	86	25.68	2.74	64	2.43	68	8.46	84	88.68	105
111	34	160	72	28.13	2.79	92	2.58	101	8.13	98	92.8	109
112	29	174	82	27.08	3.06	80	2.76	85	9.62	101	90.19	106
113	25	175	89	29.06	3.92	98	3.78	109	9.91	100	96.42	111
114	23	163	60	22.58	3.18	98	2.87	106	5.91	69	90.25	107
115	26	168	63	22.32	3.17	93	2.88	102	9.34	106	91.13	109
116	23	175	90	29.39	3.92	98	3.78	109	9.91	100	96.42	111
117	29	169	69	24.16	3.16	85	3.13	97	8.29	88	99.05	113

SL NO	age	Ht	Wt	BMI	FVC (L)	% PRED	FEV_1 (L)	% PRED	PEFR (L/S)	% PRED	FEV_1/FVC (%)	% PRED
118	34	160	52	20.31	3.06	95	2.96	95	8.6	98	87.9	99
119	25	168	52	18.42	2.99	82	2.68	84	7.06	75	89.93	103
120	25	162	56	21.34	3.06	95	2.69	95	8.6	98	87.9	99
121	32	160	59	23.05	2.95	99	2.66	108	8.29	101	90.47	108
122	25	170	68	23.53	4.58	123	4.4	135	11.45	121	96.06	110
123	40	179	69	21.53	3.26	88	3.23	100	8.17	86	99.07	113
124	25	156	55	22.60	3.02	100	2.98	111	6.94	81	98.67	111
125	35	180	76	23.46	2.61	65	2.51	76	6.88	71	96.53	116
126	25	169	69	24.16	3.16	85	3.13	97	8.29	88	99.05	113
127	29	163	70	26.35	3.08	95	2.76	99	7.35	84	89.61	104
128	29	175	87	28.41	3.6	90	3.6	104	11.06	112	100	115
129	32	176	74	23.89	3.13	83	2.93	94	7.77	83	93.91	113
130	30	169	70	24.51	3.88	104	2.93	90	7.85	82	75.51	85
131	28	174	72	23.78	3.23	85	2.9	89	10.62	112	90.06	105
132	30	176	72	23.24	2.99	79	2.78	89	8.04	86	93.28	112
133	26	168	50	17.72	2.47	68	2.43	76	6.37	68	98.78	113
134	24	152	50	21.64	2.87	101	2.87	112	4.95	60	100.34	111
135	26	160	52	20.31	2.88	90	2.64	93	8.6	98	91.66	104
136	40	178	68	21.46	4.41	118	4.35	134	10.22	108	98.86	113
137	33	164	68	25.28	2.39	73	2.17	79	7.1	82	91.17	108
138	30	162	60	22.86	2.47	72	2.22	77	6.04	68	90.24	107
139	35	167	73	26.18	2.55	75	2.26	80	5.56	63	88.97	106
140	29	168	66	23.38	3.28	92	3.04	99	9.73	106	92.68	107
141	30	158	77	30.84	3.26	112	2.93	121	6.13	76	89.87	107
142	30	165	64	23.51	3.16	95	2.84	102	9.39	107	89.87	106
143	29	176	68	21.95	4.07	109	4.07	125	10.49	110	100.24	115
144	36	182	96	28.98	3.13	74	2.89	82	6.88	69	92.62	110
145	28	169	70	24.51	3.39	92	3.32	103	9.56	101	98.22	112
146	34	170	78	26.99	3.17	87	3.17	100	9.29	99	100.31	114
147	34	163	50	18.82	2.22	65	2.21	74	5.84	65	99.54	113
148	32	165	64	23.51	2.98	90	2.73	98	7.77	89	91.61	108
149	35	168	82	29.05	2.96	83	2.57	84	9.67	106	86.82	101
150	36	185	86	25.13	3.08	70	2.87	89	7.35	71	87.53	89
151	28	172	62	20.96	2.55	75	2.26	80	5.56	63	88.97	106
152	26	178	67	21.15	3.24	89	3.17	100	9.34	100	97.83	112
153	27	150	52	23.11	3.05	116	2.72	118	5.11	65	89.47	101
154	29	168	59	20.90	2.79	77	2.79	88	7.29	78	100.35	114
155	36	158	73	29.24	3.26	112	2.93	121	6.13	76	89.87	107
156	35	164	67	24.91	3.18	98	2.87	106	5.91	69	90.25	107
157	32	168	70	24.80	2.85	78	2.81	88	7.49	80	98.94	113

SL NO	age	Ht	Wt	BMI	FVC (L)	% PRED	FEV_1 (L)	% PRED	PEFR (L/S)	% PRED	FEV_1/FVC (%)	% PRED
158	34	165	70	25.71	2.88	82	2.75	90	6.74	73	95.48	109
159	36	170	69	23.88	3.16	85	3.13	97	8.29	88	99.05	113
160	31	160	68	26.56	3.05	94	2.8	98	8.51	97	92.1	104
161	23	163	68	25.59	3.11	85	2.78	87	8.98	98	89.67	102
162	31	156	50	20.55	2.61	86	2.61	97	5.7	67	100.38	118
163	21	168	58	20.55	3.09	85	2.68	84	6.94	74	87.01	99
164	32	178	74	23.36	4.03	99	3.29	95	9.79	99	81.84	96
165	32	166	69	25.04	2.25	68	2.18	79	7.63	88	97.32	116
166	32	174	78	25.76	3.78	100	3.12	98	9.67	103	82.53	97
167	29	180	70	21.60	3.44	81	2.99	81	8.17	79	86.91	99
168	29	169	84	29.41	2.69	76	2.54	86	9.03	100	94.77	112
169	30	185	76	22.21	3.17	73	2.18	60	8	78	68.98	82
170	28	168	68	24.09	3.11	85	2.78	87	8.98	96	89.67	102
171	35	169	70	24.51	3.43	92	2.99	92	7.59	80	87.42	99
172	28	168	52	18.42	3.09	85	2.68	84	6.94	74	87.01	99
173	26	163	78	29.36	2.84	84	2.78	93	6.94	77	97.88	111
174	35	172	80	27.04	3.04	79	2.85	84	7.42	76	93.73	106
175	28	175	80	26.12	3.08	77	2.7	77	7.49	75	87.66	100
176	39	172	73	24.68	2.96	77	2.96	88	8.04	83	100	113
177	34	165	72	26.45	2.61	65	2.47	70	5.4	54	95	108
178	25	155	58	24.14	3.01	75	2.77	79	7.56	76	92.33	105
179	32	165	63	23.14	3.39	84	3.17	91	6.97	70	93.78	107
180	26	163	78	29.36	2.75	81	2.75	92	5.87	65	100.36	114
181	29	170	63	21.80	3.72	99	3.4	103	7.49	78	91.39	103
182	32	182	70	21.13	3.47	79	3.1	82	7.63	73	89.59	103
183	26	170	52	17.99	2.7	72	2.62	81	8.88	94	97.03	111
184	21	170	64	22.15	3.1	83	3.05	94	7.89	83	98.38	113
185	34	168	59	20.90	3.2	93	3.14	109	8.17	92	98.12	116
186	27	168	67	23.74	3.17	90	3.13	103	8.21	90	99.05	115
187	29	167	59	21.16	3.29	95	3.11	105	8.25	92	94.81	110
188	34	163	68	25.59	3.15	99	3.09	116	8.29	97	98.4	117
189	36	167	67	24.02	3.22	96	3.14	112	8.29	95	97.51	116
190	35	160	62	24.22	3.11	102	2.49	98	8.29	100	80.32	95
191	31	167	64	22.95	3.17	92	3.13	108	8.51	95	99.05	117
192	35	160	62	24.22	3.07	101	3.05	121	8.33	101	99.67	118
193	38	142	60	29.76	3.35	162	3.13	179	8.21	119	93.71	110
194	28	162	58	22.10	3.14	98	3.08	111	7.89	91	98.08	113
195	29	160	60	23.44	3.17	102	3.11	116	8.25	97	98.41	114
196	27	145	54	25.68	3.28	137	3.12	148	8.08	108	95.12	107
197	29	168	60	21.26	3.19	91	3.1	104	8.04	89	97.48	114

SL NO	age	Ht	Wt	BMI	FVC (L)	% PRED	FEV_1 (L)	% PRED	PEFR (L/S)	% PRED	FEV_1/FVC (%)	% PRED
198	28	159	57	22.55	3.24	105	3.17	120	8.33	98	97.83	113
199	21	149	51	22.97	3.23	144	3.12	179	8.38	121	96.89	124
200	23	154	56	23.61	3.17	110	3.08	121	7.66	92	97.46	110